HYDROLOGICAL PROCEDURE NO. 26

ESTIMATION OF DESIGN RAINSTORM IN SABAH AND SARAWAK

1983

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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Bahagian Parit dan Taliair
Kementerian Pertanian, Malaysia

ESTIMATION OF DESIGN RAINSTORM IN SABAH AND SARAWAK

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Price: $10

Published by:

Publication Unit, Ministry of Agriculture,
Jalan Mahameru, Kuala Lumpur

1983

DICETAK OLEH HAJI MOKHTAR SHAMSUDDIN, J.S.D., S.M.T., K.M.N., P.I.S.,
KETUA PENGARAH PERCETAKAN NEGARA, KUALA LUMPUR
1984

SYNOPSIS

Analysis was carried out on available data from the existing network of rainfall stations in Sabah and Sarawak. The result of the analysis is presented in the form of isopleth maps and rainfall intensity-duration-frequency curves.

These maps and curves form the basic working tools for the estimation of design rainstorms. An explanation of the theory and methodology involved is given. Also presented are worked examples to illustrate the steps involved in the use of this procedure.

CONTENTS

PART I—FREQUENCY ANALYSIS OF RAINFALL DATA

1.1 INTRODUCTION

1.1.1 General

This part of the procedure deals with the general methodology involved. Basic statistical concepts are presented for those readers with no experience in the theory and application of statistics to engineering problems, although the treatment is necessarily brief.

The methodology and results of the frequency analysis, and the inherent limitations of the procedural details are also discussed. It is important for the user to realise the problem of uncertainty in hydrological design so that the practical implications to the design of structures can be properly appreciated.

1.1.2 Notation

Most of the statistical terms used are defined within the context of their presentation. It is useful at this point, however, to introduce the notation used in connection with the design rainstorm:

(i) X (T, t) is the rainfall depth (in mm.) of a storm with an estimated return period of T years and having a duration of t hours. Note that return period is defined in Section 1.2.2.

(ii) X (20, 3) hence represents the depth of a "20 year storm" lasting for 3 hours.

(iii) X (20) denotes the "20 year" estimate of the storm whose duration is specified elsewhere (i.e. not needed in the context of the presentation).

1.2 OUTLINE OF THEORY

1.2.1 General

The use of recording raingauge data as basis for a procedure to estimate the design rainstorm involves probability theory. The particular theory used in this study is known as the Gumbel Theory of Extreme Values, and a great deal has been written about the theory and its use for the development of this procedure follows closely the methods used in many overseas countries for the treatment of short duration rainfall data (Robertson, 1963; Reich, 1963).

In this section the theoretical aspects pertinent to the study are outlined briefly. For a more detailed treatment reference should be made to the papers given above.

1.2.2 Probability and Return Period

A sample of hydrological data may be a continuous record or a series of discrete events over the period of measurement. The data are termed historic data, in that they result from natural phenomena and are not repeatable, as distinct from some types of experimental data which may occur under controlled conditions and may be repeatable.

Probability theory is related to the study of the chance of occurrence of the phenomena based on the sampled data. As is probably obvious, the greater the length of a data record in time, the more confident one can be about estimates of the probability of occurrence of the phenomena, assuming that the conditions affecting the data do not change with time.

1.2.2.1 *Probability Considerations of Hydrological Events within a Sample*

If we consider a hydrological variable, such as rainfall, and denote it by X, then an individual value of X can be denoted as x (e.g. x = 50 mm.). The observations of X over a certain period may be regarded as statistical trials, and the values of the variable X $(= x_1, x_2, x_3...)$ can be considered to be random variables. Hydrological variables are both random and continuous, in that they can take "every possible" value over a certain range. The hydrological variable being considered in this study is defined for discrete time periods (e.g ¼, 3, 24 hr. rainfall depths). Hence for each time period there is a continuous random variable X_t (t = ¼, 3, 24 etc.).

The occurrence of a value of the variable within a certain range is called an event. The number of occurrences of an event in a total population of events, is called the frequency of the event. For example, the event may be defined as the number of days in the month when the rainfall was equal to or less than 100 mm. (denote this number by r). The population may be considered to be the number of days in the month, denoted by L. The probability of the event (that is of daily rainfall being equal to or less than 100 mm.) is r/L

$$\text{Rewriting this } P(x) = \frac{r}{L}$$

where P (x) is the probability that $X \leqslant x$ (in this case $X \leqslant 100$)

Pursuing this aspect a little further, we can reason that the number of days in the month when the daily rainfall is either equal to or less than 100 mm., or greater than 100 mm., equals the number of days in the month.

$$\text{i.e. } P(X \leqslant x) + P(X > x) = \frac{L}{L} = 1$$

$$P(X > x) = 1 - P(X \leqslant x) = 1 - P(x)$$

The estimates of the probability of occurrence of particular values of the phenomena can be expressed as "return period estimates". The return period is the average interval of time (in years) between the years that contain an event greater than or equal to the one under consideration. That is, if the return period of a 3 hr. rainstorm depth of 100 mm. is 5 years, then this indicates that an average period of 5 years will elapse between the occurrence of a 3 hr. rainstorm with depths greater than or equal to 100 mm.

The relationship between return period and probability is defined by

$$T(x) = \frac{1}{1 - P(x)} \quad \text{...........(1)}$$

where P (x) = probability that $X \leqslant x$ (as above) in any one year.

1.2.2.2 *Probability Considerations in Taking Samples of Hydrological Events from the Population*

For the particular record (1 month) considered above, make r = 27 and L = 30

$$\text{Then } P(x) = \frac{27}{30} = \frac{9}{10} = 0.90$$

This means that if we select one value at random from the month record (say by selecting one daily card from 30 cards), there is a 9/10 chance that it would be a day with rainfall equal to or less than 100 mm.

It would be even less likely to draw 2 cards, independently, from the month and find both of them $\leq$ 100 mm. The probability of this event = P (x) .P (x)

$$\frac{9}{10} \times \frac{9}{10} = \frac{81}{100} = 0.81$$

It can be shown that, for a large population from which N independent observations are made, each with a probability of P (x), the probability that they will all fail to exceed the value of x is $[P(x)]^N$ [let us call this $P_N(x)$]. That is, if a sample of N values is selected from the population at random, $P_N(x)$ is the probability that the largest value in the sample $\leq$ x.

Hence, if we select n random samples from the population, each of size N, the series of largest values (from each sample) forms a set of random variable $x_1, x_2, \ldots x_n$ whose probability function is $P_N(x)$. The distribution of the largest values can be seen to depend upon N (the size of sample), and the form of the initial distribution P(x).

1.2.2.3. *Extreme Value Theory*

It is the new population, that of the largest value in group of samples of size N drawn from the parent population, that is now our concern. Gumbel has shown that if the size of the sample, N, is very large, the distribution of the largest values in each sample is not dependent on the exact form of the initial distribution. For a large number of common initial distributions it tends towards one of three forms.

The Gumbel type I distribution has been assumed to represent the form of the distribution of the largest depth of storm rainfall of a particular duration, for each selected 12 month period. This distribution has a probability relationship of:

$$P(x) = \exp(-e^{-y}) \quad \text{.......... (2)}$$

$$\text{where } y = \alpha(x-u) \quad \text{.......... (3)}$$

y is known as the "reduced variate" and x and u are parameters which may be estimated from the observed largest values.

1.2.3 **Application of Gumbel Theory to Rainfall Analysis**

The assumption of the mathematical form of the probability distribution of the annual maximum rainfall [Eqn (2)] makes possible:

(i) Estimates of values of the variate for a particular probability of occurrence.

(ii) Assessment of the confidence that can be placed upon such estimates.

1.2.3.1 *Gumbel Extreme Probability Paper*

The method used in this study (one of several available) to estimate the parameters of the assumed probability distribution involves the use of special probability plotting paper. Probability distributions of the Gumbel Type I, plot as straight lines on this paper. The horizontal axis of the plotting paper can be presented showing three related scales.

(i) A linear y scale (y being the reduced variate)

(ii) A probability scale on which the graduations are related to the linear y scale by equation (2).

(iii) A return period scale related to the probability scale by equation (1). The vertical scale is a linear scale of the value of the variate. The method consists of plotting the data points on the plotting paper and of fitting a straight line to the plotted points.

1.2.3.2 *Plotting Position*

To plot data with a particular real measured value on the plotting paper, they must be assigned a return period. This is done by ranking the data in descending order (highest to lowest) and assigning each data value a rank (m), giving rank (m = 1) to the largest value, rank (m = 2) to the second largest value, and so on.

The return period estimate for plotting purposes is calculated using one of the various formulae discussed by Gumbel (1960):

$$T = \frac{n+1}{m} \quad \text{...........(4)}$$

Where T is the return period in years and n is the number of annual maximum values of the phenomena.

1.2.3.3 *Fitting a Straight Line to the Plotted Points*

A straight line is fitted to the plotted points by the modified least square method where both the vertical and horizontal departures are minimised. This is expected to give better fitting than the classical least square method where only vertical or horizontal departures are minimised.

1.2.3.4 *Confidence of Estimates Made from Data*

The computed value of an event for a certain return periods is not the "real" value, and has a certain statistical uncertainty attached to it. This uncertainty is normally expressed by plotting two control curves on either side of the plotted line. The position of these curves is such that the vertical distance from the line to each curve is equal to the standard error of the m^{th} ranked observation, drawn from a population whose cumulative probability function is represented by the theoretical line.

If the plotted data points lie within the control curves, which are constructed from the estimated parameters of the assumed cumulative probability function, the fit of the data points to the theoretical line is considered satisfactory. The implication of the control curves can be expressed in another way. Having accepted the reasonableness of the theoretical approximation, it is useful to know the confidence that may be afforded to estimates of rainfall depth made for various return periods. A vertical line from a particular return period cuts the theoretical line and the two control curves. The estimate is then the value for the theoretical line intersection, with ⅔ probability that the confidence band contains the value.

It has been shown (Robertson, 1963) that the control curves can be constructed in the following way:

(i) Read off X(20) and X(2) from the fitted line (refer to Section 1.1.2 for a definition of these terms).

(ii) Compute D = X(20) − X(2).

(iii) Compute standard error (vertical distance from the fitted line to the control curves) according to Table 1-1.

TABLE 1-1: DATA USED FOR THE CONSTRUCTION OF CONTROL CURVE FOR FITTED GUMBEL TYPE 1 DISTRIBUTIONS

	RETURN PERIOD (T) YEARS					
	2	5	10	20	n	50
Standard error	$\frac{0.54D}{\sqrt{n}}$	$\frac{0.86D}{\sqrt{n}}$	$\frac{1.23D}{\sqrt{n}}$	$\frac{1.73D}{\sqrt{n}}$	0.43D	0.43D

(iv) This Table applies strictly only when $n \geqslant 20$.

(v) For $n \geqslant 20$, the control parallels the extrapolated section of the line at a distance equals to 0.43D after T = n. This applies to most of the data used for this study of the total of 171 stations, having records less than 20 years.

1.3 ANALYSIS OF DATA

1.3.1 Origin of Data

Data for the study comes from a network of rainfall stations covering Sabah and Sarawak maintained by the Drainage and Irrigation Department (DID), the Malaysian Meteorological Service (MMS) and other agencies. The network comprises stations with manually-read raingauges (manual stations) read daily at 0800 hours and stations equipped with automatic recording raingauges (automatic recording stations) giving continous rainfall records.

Altogether 155 manual stations, 54 from Sabah and 101 from Sarawak, were selected for the study. However for automatic recording stations only 16 were selected, 8 from each state. A summary of the data used in the study is given in Appendix A.

1.3.2 "Short Duration" and "Long Duration" Analysis

From automatic recording stations, rainfall with durations ¼, ½, 1, 2, 3, 6, 12, 24, 48 and 72 hours were extracted. From manual stations rainfall of durations 1, 2, 3, 5, 7, 14 and 30 days were extracted.

These two sets of data were treated and analysed separately. For convenience in references, analysis of data from automatic recording stations will be referred to as "short duration" analysis while analysis of data from manual stations will be referred to as "long duration" analysis.

1.3.3 Data Extraction for Frequency Analysis

For each year, the maximum rainfall depths corresponding to durations mentioned in section 1.3.2 were extracted. For the "long duration" analysis, data extracted was based on the water year which begins on 1st July and ends on 30th June the following year while for the "short duration" analysis data was extracted based on the calendar year.

1.3.4 Rainfall Depth-Duration-Frequency Analysis

The data were analysed according to the theory outlined in section 1.2. Calculations, plotting of points and drawing of the best-fit line by method of moments as well as goodness of fit tests, based on Chi-Square and Smirnov-Kolmogorov methods, were conducted on the NOVA 1220 computer. The computer program output consists of plots on extreme probability paper and listings of estimated depths of storm of a certain duration for return period of 2, 5, 10, 20 and 50 years. The results for "long duration" analysis and for "short duration" analysis are given in Appendix B and Part 2.3 respectively.

Note that the 24, 48 and 72 hour duration rainfalls in the short duration analysis have the same duration as the 1, 2 and 3 day duration rainfalls in the long duration analysis. This apparent repetition of analysis has its reasons.

As the parameter of interest in the analysis is the maximum rainfall occuring within a certain duration regardless of the starting time of rainfall, the values extracted from automatic recording stations which have continuous records would be more accurate than the values extracted from manual stations where records are read daily at a fixed observation time (0800 hrs.). Therefore it is recommended that the results from "short duration" analysis which uses data from automatic recording stations be used whenever possible. However the density of automatic recording stations is too sparse to allow accurate extrapolation of results to locations remote from these stations. To improve the accuracy of extrapolation of data to locations without stations, analysis of 1, 2 and 3 day duration rainfalls was carried out on data from manual stations to supplement the results from short duration analysis.

1.3.5 Adjustment of 1, 2 and 3 Day Annual Maximum Rainfall Records from Manual Stations

The 1, 2 and 3 day annual maximum rainfalls used in the long duration analysis come from manual stations with raingauges, read daily at a fixed observation time which is at 0800 hours. Annual maximum rainfalls derived from such stations may not represent the true maximums as it is very unlikely that the annual maximum rainfall over the durations mentioned would occur exactly between the fixed observation time. The annual maximum rainfall from manual stations would normally be less than its true maximum and adjustments have to be made to these data before analysis.

A study of this had been carried out for Peninsular Malaysia using 9 years of records (July 1970-June 1979) from 25 stations. Adjustment factors (F) were derived for annual maximum rainfall of various durations (D) such that:

True annual maximum rainfall of duration D
= Annual maximum rainfall of duration D from manual stations × F

Factors F corresponding to durations D determined from the study is shown in Table 1-2.

TABLE 1-2: VALUES OF ADJUSTMENT FACTOR F FOR VARIOUS RAINFALL DURATIONS

Duration of Annual Maximum rainfall (D) (hrs.)	*Adjustment Factor (F)*
24	1.14
48	1.08
72	1.06

As Sabah and Sarawak are subjected to similar climatic influences as Peninsular Malaysia the above factors were used for adjusting the annual maximum rainfall data used in the "long duration" analysis. In the same study mentioned above, it was found that for durations of 5 days or more the differences between the true annual maximum and the maximum extracted from manual stations is insignificant and hence no adjustments need to be made.

1.4 DISCUSSION OF RESULTS

1.4.1 Errors

Recording errors resulting from partial blockage of the recorder funnel, poor syphoning and errors in the time base, are often difficult to detect. Gross errors in total volume recorded on a daily basis can be detected from records of manual check gauges normally installed beside recorders. Other errors are often obvious from the recorder trace, and can be allowed for.

A more serious and irremovable error is introduced by poor resolution of the chart time scale, especially for short duration rainfall values. Much of the data used are from Kent Weekly recorders with a chart time scale of 56.5 mm./24 hr. The Casella weekly recorders (type no. 467) have a chart time scale of 37.5 mm./24 hr. Depending on the rainfall intensity, errors of manual reading or of processing through electronic digitiser can reach up to 15% for storm depths extracted for duration of ¼ and ½ hr. Concurrently, misalignment of the pen/float shaft can cause errors in the time scale of the record, which may not be systematic. The combined maximum likely error in depth estimates (from these two causes) for short duration rainfall is not likely to exceed 20%, with lesser errors for storms of longer duration.

1.4.2 Uncertainty

The most serious limitation to the usefulness of this investigation is still the short period of record of data available for analysis. This aspect can only be remedied with the passage of time. The treatment of the confidence limit calculations outlined in Section 1.2.3.4, does however allow the goodness of fit of the sampled data to the theory to be assessed using visual criteria. The Chi-Square and the Smirnov-Kolmogorov tests serve further confirmation of goodness of fit. More importantly, the confidence of the estimates made from the data can be expressed quantitatively. Several example of the scale of this uncertainty for stations used in the investigation are given in Table 1-3, calculated using the relationship listed in section 1.2.3.4.

TABLE 1-3: EXAMPLES OF THE UNCERTAINTY OF X (T, t) VALUES FROM ACTUAL RECORDS

Station Number	*Years of record*	*Duration (hrs.)*	*Computed Estimates (MM.)*			*Estimate and 2/3 Probability Range for Return Period shown (Yrs)*		
			X_{20}	X_2	*D*	*2*	*10*	*20*
1704013	19	24	364	210	153	210 ± 19	321 ± 43	364 ± 66
3451028	10	24	159	104	55	104 ± 9	144 ± 22	159 ± 24
5274001	6	24	223	118	105	118 ± 23	194 ± 45	223 ± 45

The order of uncertainty of the estimates can be appreciated from the above figures, with the effect of the period of record on the confidence estimates amply demonstrated by the range for Station No. 5274001 (6 yrs. record).

1.4.3 Conversion of Point Rainfall Estimates to Areal Average Estimates

Although a limited study of storm rainfall variation with area had been carried out (DID, 1970) based on daily raingauge totals in Selangor, the results are not complete enough for use in a generalised design procedure.

The conversion of point rainfall estimates to average catchment rainfall estimates could be based on factors shown in the Table 1-4 (U.S.W.B., 1957-58)

TABLE 1-4: VALUES OF AVERAGE CATCHMENT RAINFALL ÷ POINT RAINFALL ESTIMATE

Catchment Area (Km²)	*Storm Duration (hrs.)*				
	½	*1*	*3*	*6*	*24*
0	1.00	1.00	1.00	1.00	1.00
50	0.82	0.88	0.94	0.96	0.97
100	0.73	0.82	0.91	0.94	0.96
150	0.67	0.78	0.89	0.92	0.95
200	0.63	0.75	0.87	0.90	0.93
250	0.61	0.73	0.85	0.89	0.93
300	0.59	0.71	0.84	0.88	0.93
400	0.58	0.68	0.81	0.86	0.92
500		0.67	0.80	0.85	0.92
600		0.66	0.79	0.84	0.91
800		0.65	0.78	0.83	0.91
1000			0.78	0.83	0.91

1 Km² = 0.386 miles².

PART 2—COMPONENTS OF THE PROCEDURE

2.1 INTRODUCTION

Results of the analysis of annual maximum rainfall data for various durations are presented in the form of isopleth maps and rainfall intensity-duration-frequency curves. These maps and curves are the basic tools of the procedure and together with the plotting diagrams they allow the user to estimate design rainstorm if the duration, return period and location are specified. These various items of the procedure are explained in detail in the following sections.

2.2 COMPONENT ONE—THE ISOPLETH MAPS

2.2.1 Description

To enable the user to estimate the rainfall depths for locations without rainfall records, 16 isopleth maps were prepared for 4 durations, and for each duration there are 4 corresponding return periods. A list of the maps for various durations and return periods is shown in the Table 2-1.

TABLE 2-1: LIST OF ISOPLETH MAPS

Figure	*Duration*	*Return Period Yrs.*
2.2.1	24 (Hrs)	2
2.2.2	24 (Hrs)	5
2.2.3	24 (Hrs)	10
2.2.4	24 (Hrs)	20
2.2.5	48 (Hrs)	2
2.2.6	48 (Hrs)	5
2.2.7	48 (Hrs)	10
2.2.8	48 (Hrs)	20
2.2.9	72 (Hrs)	2
2.2.10	72 (Hrs)	5
2.2.11	72 (Hrs)	10
2.2.12	72 (Hrs)	20
2.2.13	7 (Days)	2
2.2.14	7 (Days)	5
2.2.15	7 (Days)	10
2.2.16	7 (Days)	20

The locations of the rainfall stations used in the study are shown on these maps to indicate the coverage of the network.

2.2.2 Limitations

Generally, the western part of Sarawak, and the coastal areas of Sabah and Sarawak are reasonably well covered by rainfall stations. The errors introduced by linear interpolation would appear to be no greater than the uncertainties inherent in the data, except where steep isopleth gradients are indicated. Magnitude of errors in these regions should not be serious. Towards the central parts and inner land masses where areal coverage of rainfall stations are not as dense, errors would be more significant.

2.3 COMPONENT TWO—"SHORT DURATION" RAINFALL INTENSITY—FREQUENCY CURVES

2.3.1 **Description**

These curves enable the user to estimate the design rainfall intensity for any selected duration between 1/4 to 72 hours and any return period between 2 to 50 years, (depending on the number of years of records that are available). Conversely the return period of an important historic rainfall may be determined when the other two components (depth and duration) are known.

At the moment, only sixteen locations have satisfactory and adequate length of records for this analysis. The locations of these stations can be found in Figure 2.3. A brief description of the stations is given in Appendix A (*d*).

Fig. 2.3.1 to Fig. 2.3.16 present a series of rainfall intensity-duration-frequency curves for the 16 (sixteen) selected locations. Curves with dotted lines are extrapolated from Gumbel frequency analysis. Attempt to utilise values beyond this in a design exercise is not recommended. For recurrence interval less than that of the extrapolated curve and not directly provided by any of the curves, interpolation can be made by using Arithmetic Gumbel Paper.

2.3.2 **Limitations**

Each rainfall intensity-duration-frequency curve is applicable directly to the site of the rainfall station at which the relevant rainfall data have been collected. The curve generally can be used for design purpose at other locations nearby and in some cases, at locations many kilometres away from the rainfall station if the rainfall station is climatically representative of the area under consideration. In such cases, the errors introduced by spartial extrapolation may not be as significant as the inherent error resulting from the chart and data processing errors and the short period of record—especially for very short duration data eg. 15 mins. and 30 mins. rain.

2.4 COMPONENT THREE—RAINFALL DEPTH/INTENSITY—FREQUENCY AND RAINFALL DEPTH—DURATION PLOTTING DIAGRAMS

2.4.1 **Rainfall Depth/Intensity—Frequency (Return Period) Plotting Diagram**

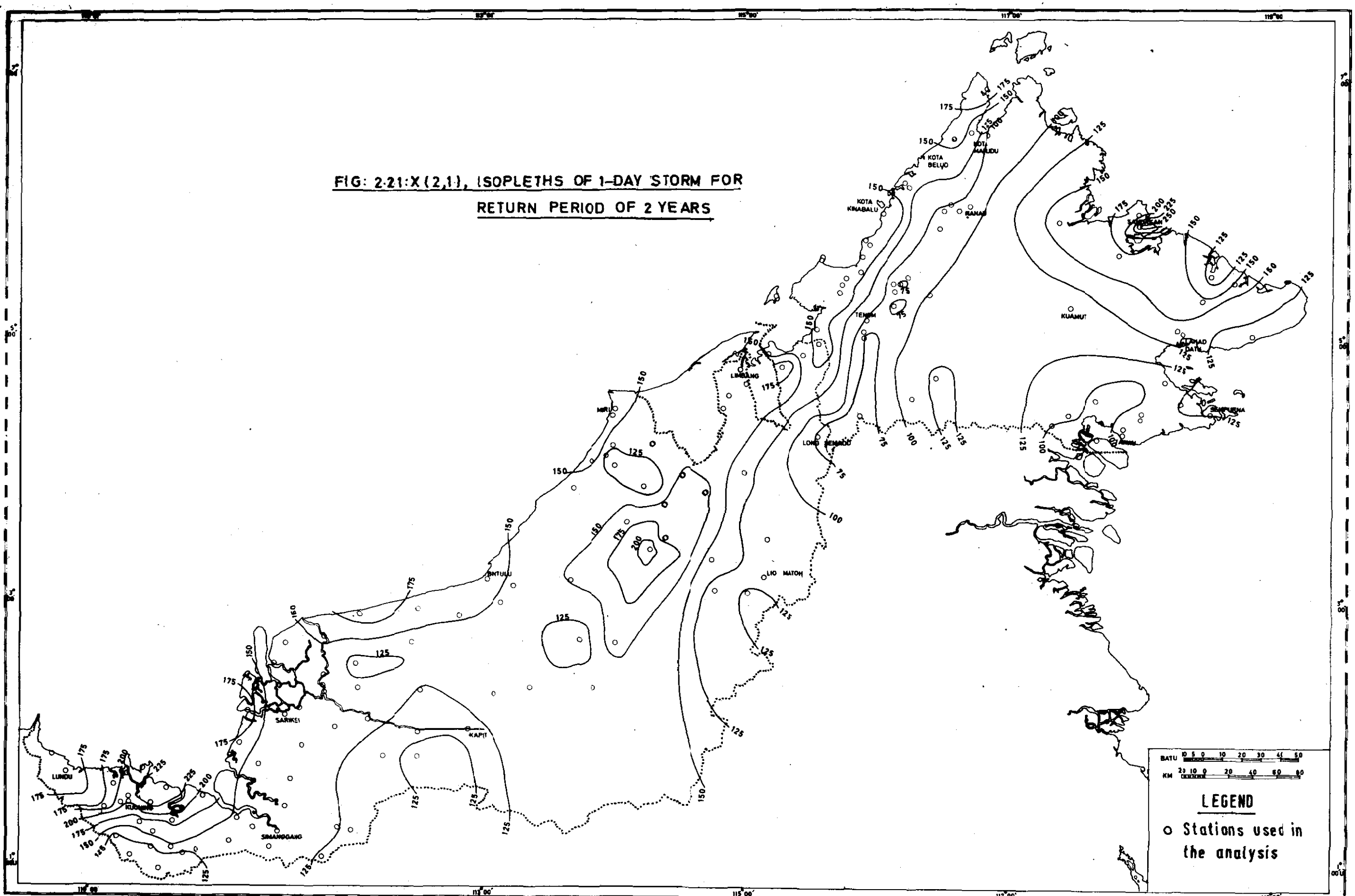
2.4.1.1 *Description*

The extreme probability paper (Gumbel Type I) used in the analysis of the data is presented in Appendix C. Rainfall depth-frequency or the rainfall intensity-frequency plots of storms having the same duration are shown as straight lines on this probability paper. Examples of such plots are presented in Figs. EX—1 (*a*) and EX—2.

2.4.1.2 *Discussion*

The use of the Gumbel Type I distribution to represent the rainfall depth—frequency relationship of annual maximum storm events is well established. Studies on rainfall data carried out in Malaysia (Lockwood, 1967) and overseas (Reich 1963) have shown that good agreement exists between recorded phenomena and the distribution.

FIG: 2·21:X (2,1), ISOPLETHS OF 1-DAY STORM FOR RETURN PERIOD OF 2 YEARS



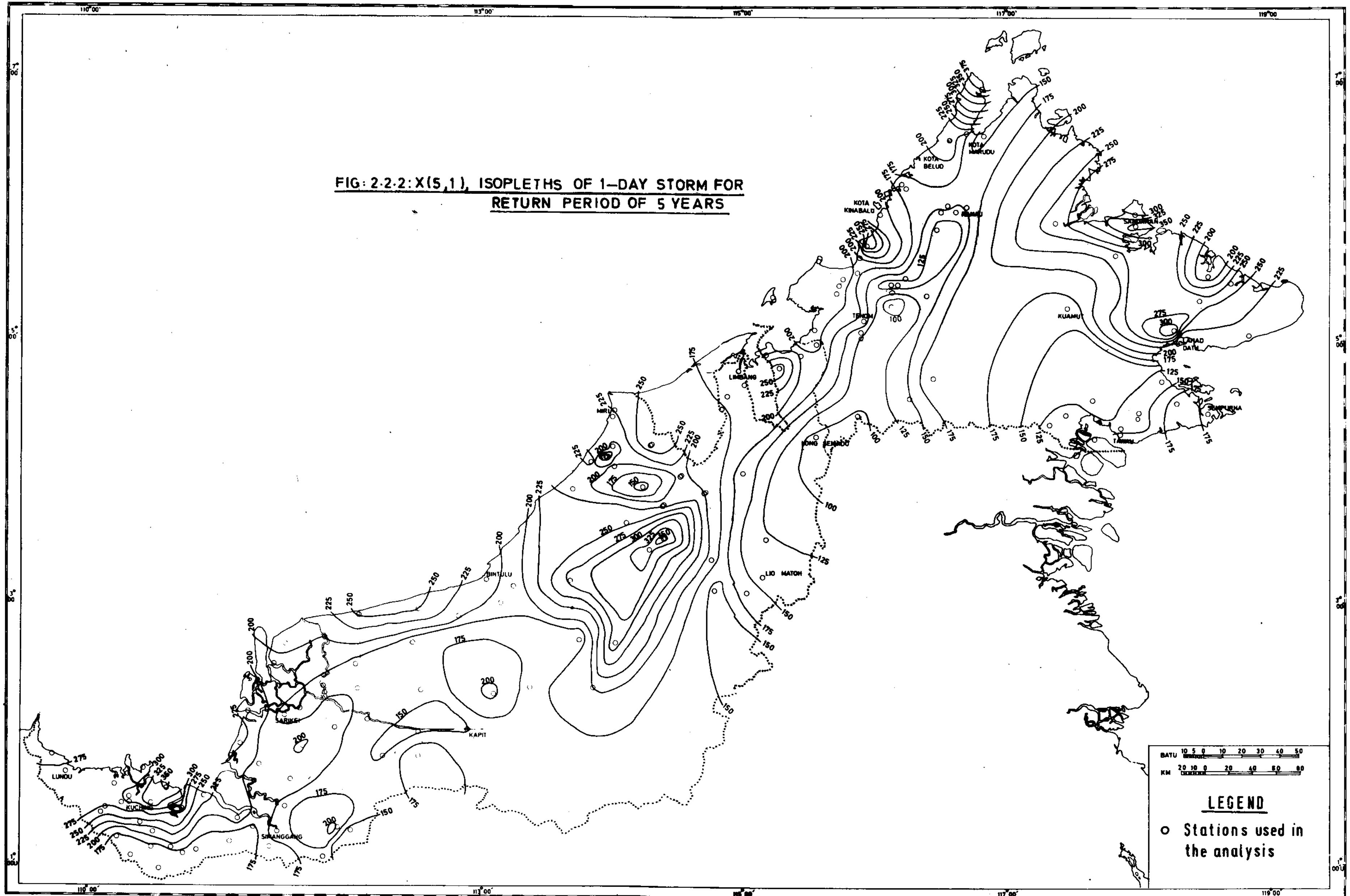


FIG: 2.2.2: X(5,1), ISOPLETHS OF 1-DAY STORM FOR RETURN PERIOD OF 5 YEARS

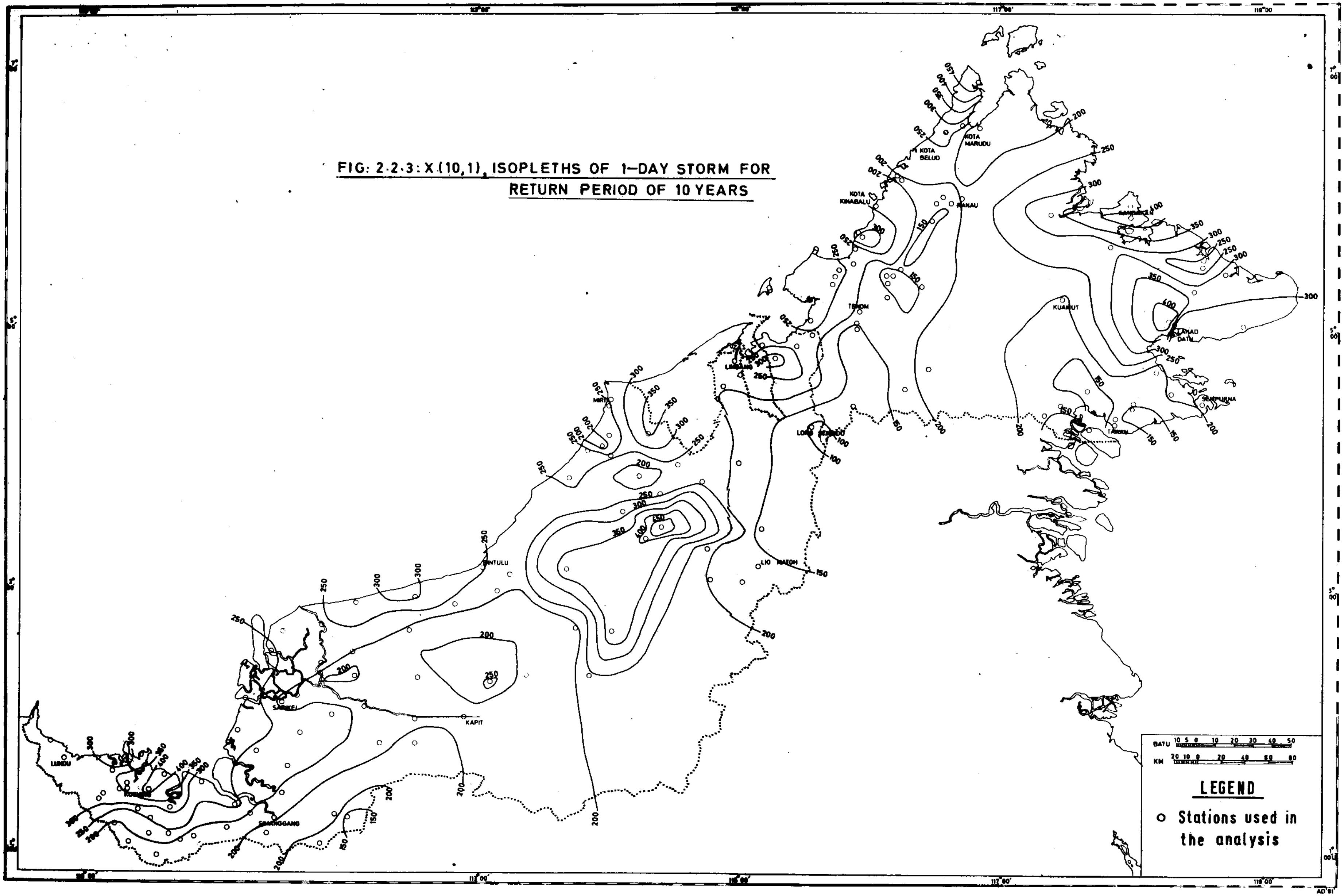


FIG: 2.2.3: X (10,1), ISOPLETHS OF 1-DAY STORM FOR RETURN PERIOD OF 10 YEARS

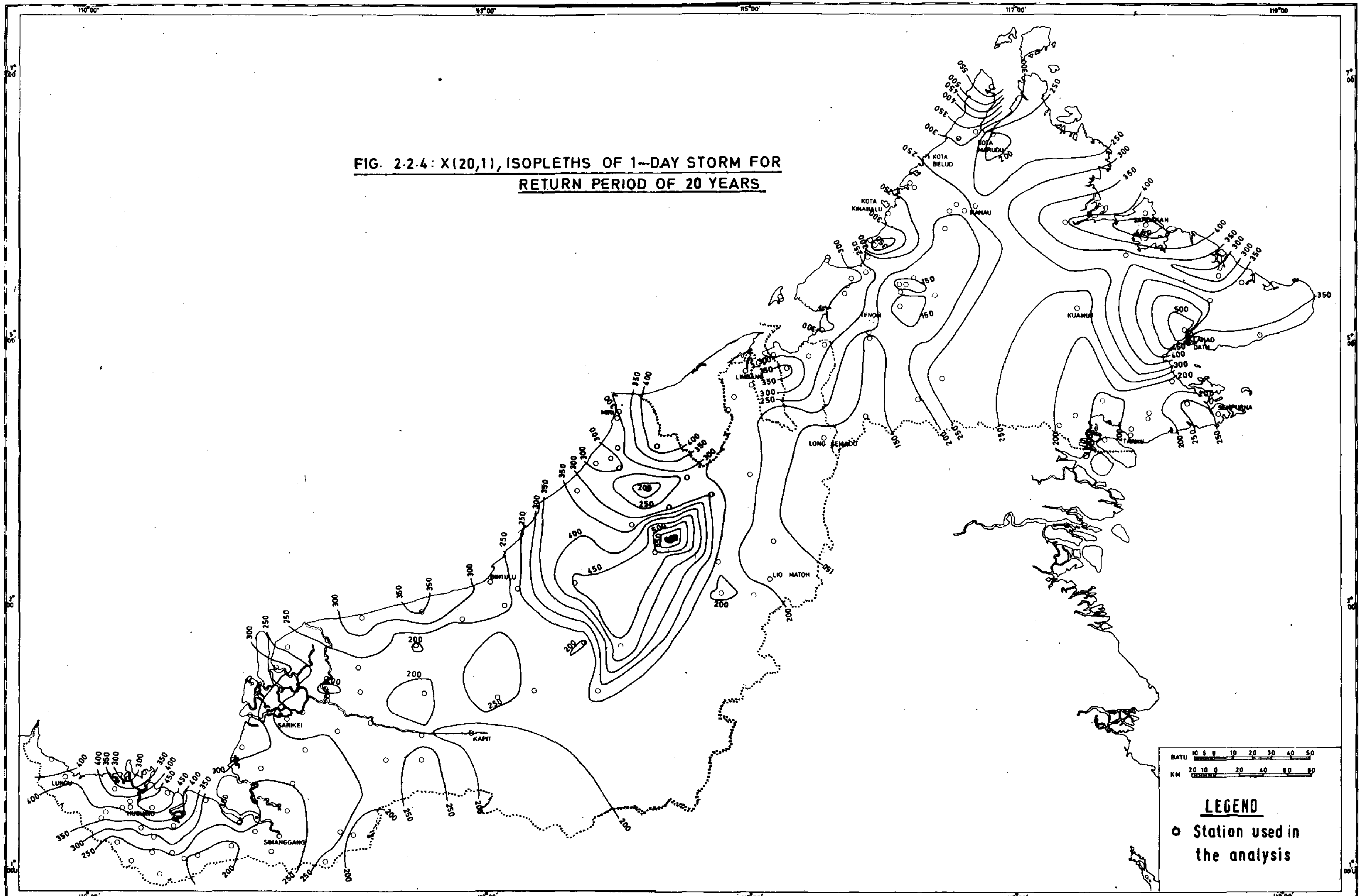


FIG. 2.2.4: X(20,1), ISOPLETHS OF 1-DAY STORM FOR RETURN PERIOD OF 20 YEARS

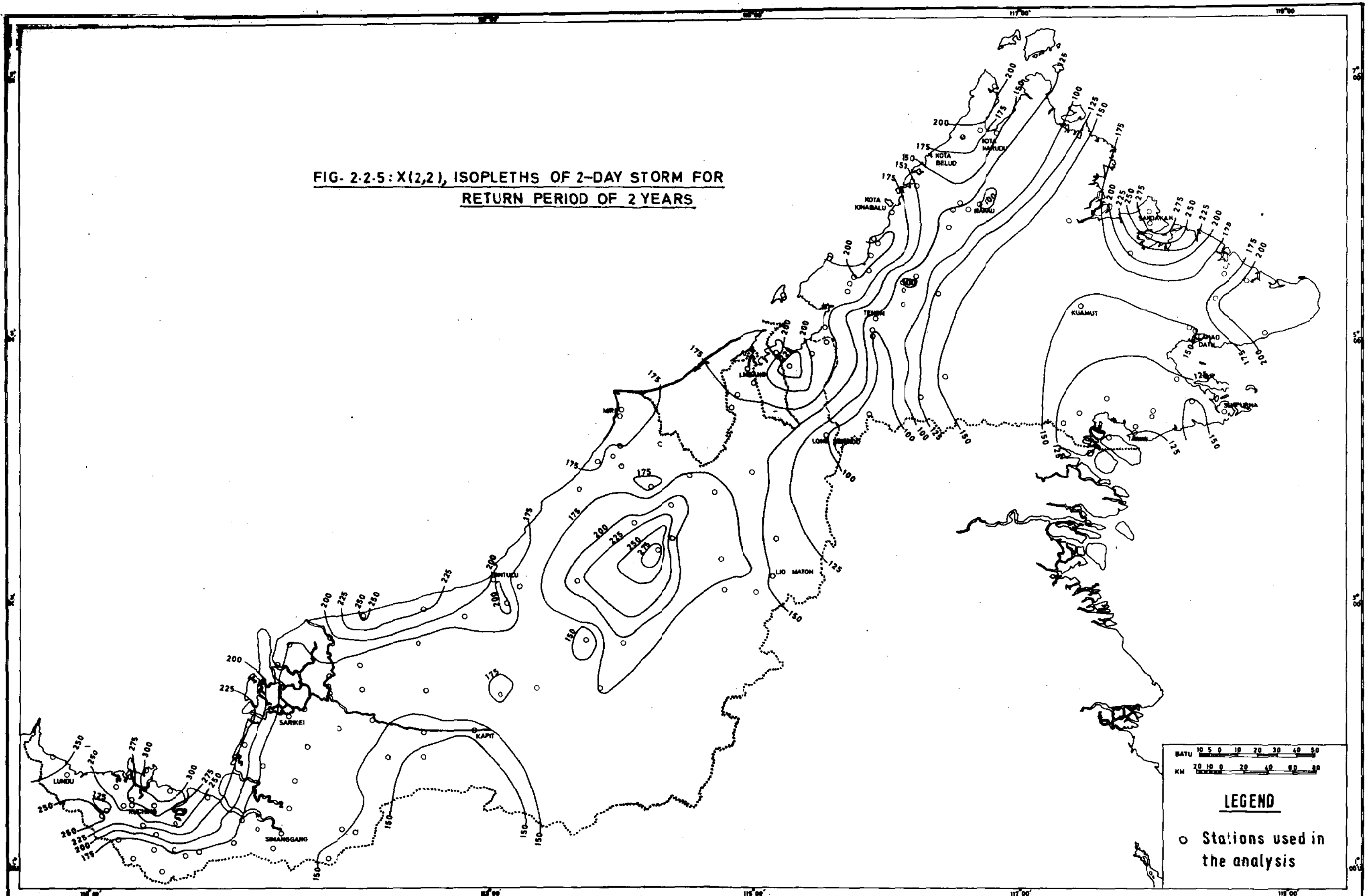


FIG. 2.2.5 : X(2,2), ISOPLETHS OF 2-DAY STORM FOR RETURN PERIOD OF 2 YEARS

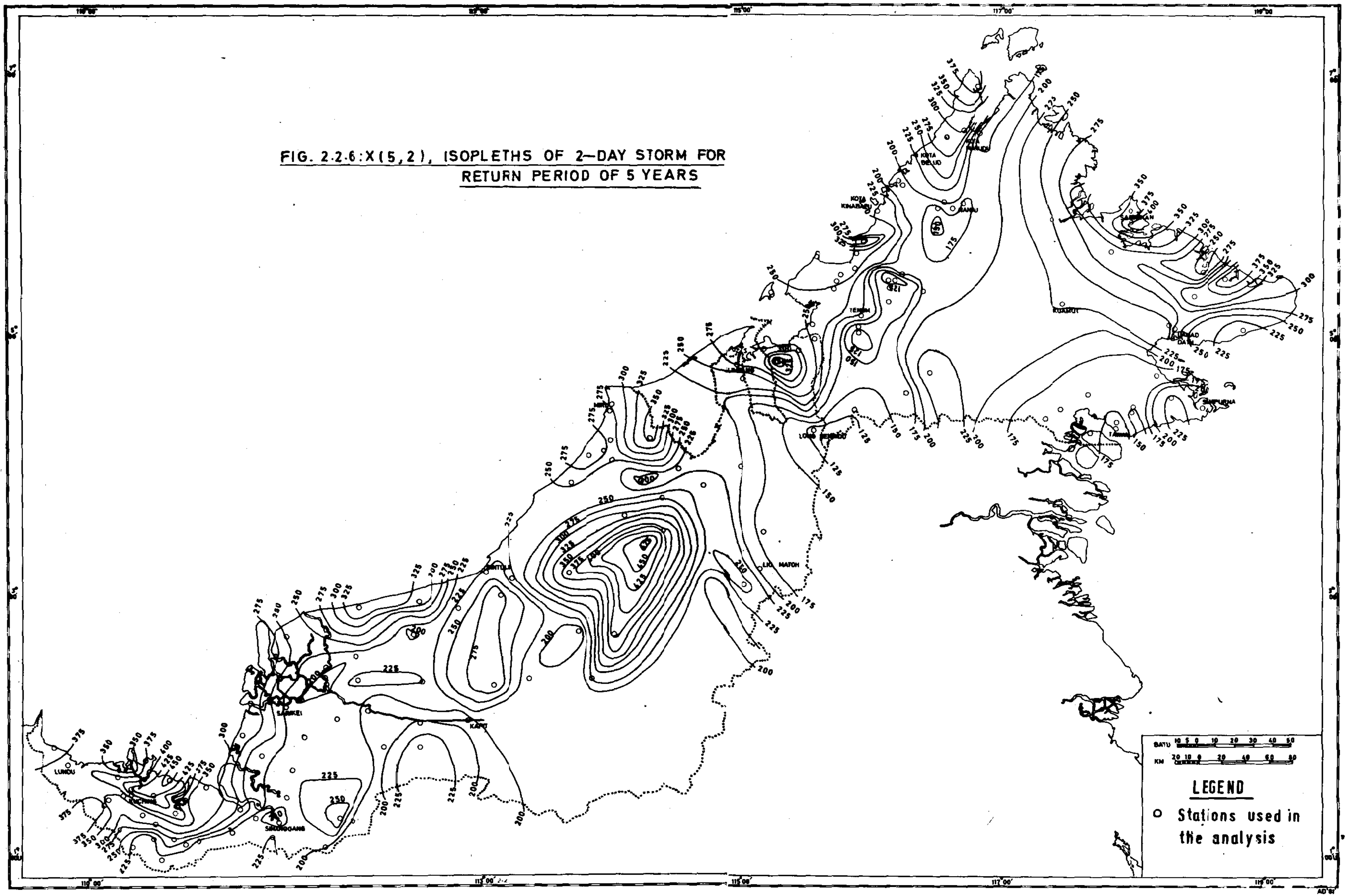


FIG. 2.2.6: X (5, 2), ISOPLETHS OF 2-DAY STORM FOR RETURN PERIOD OF 5 YEARS

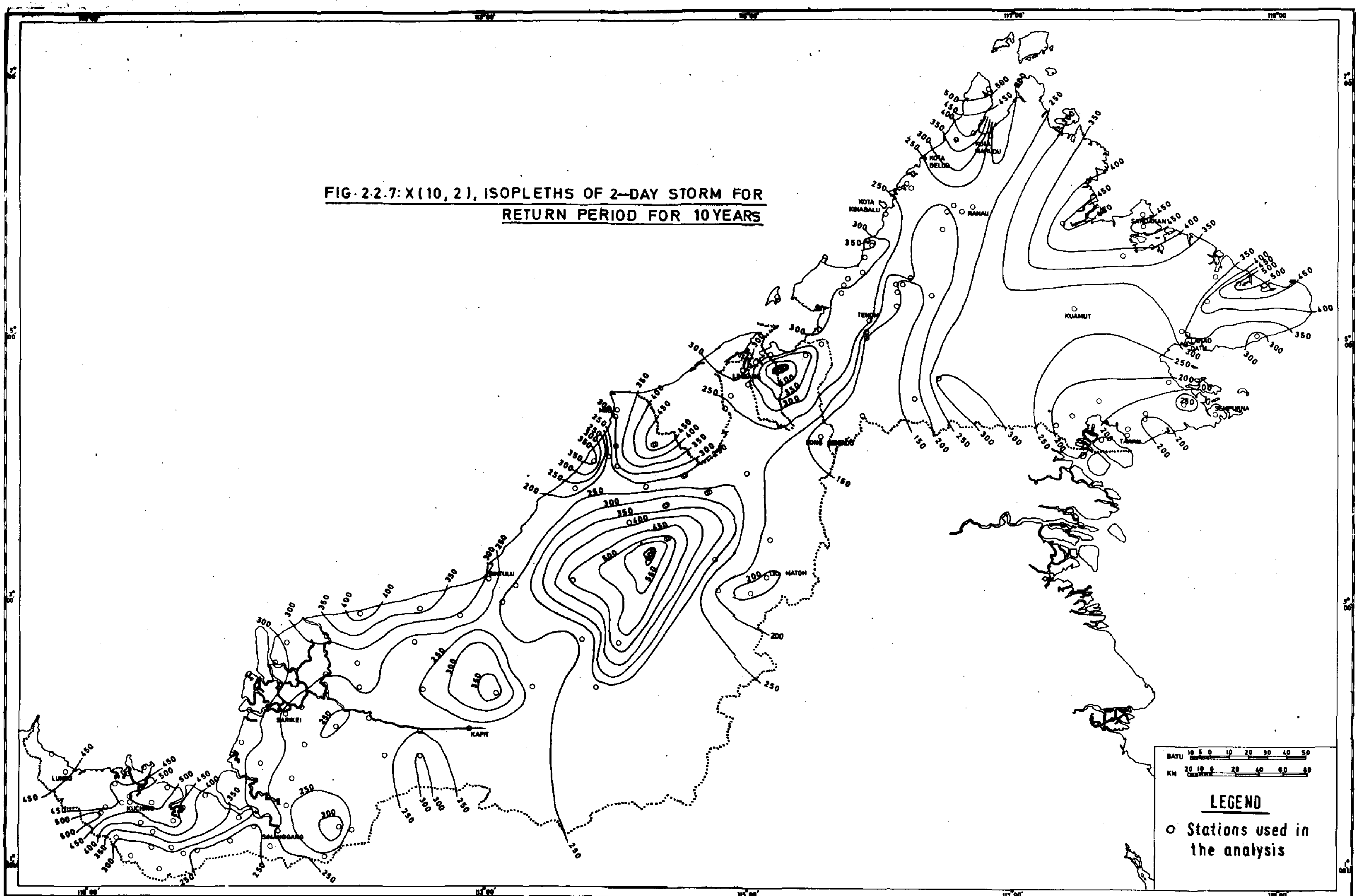


FIG. 2.2.7: X(10, 2), ISOPLETHS OF 2–DAY STORM FOR RETURN PERIOD FOR 10 YEARS

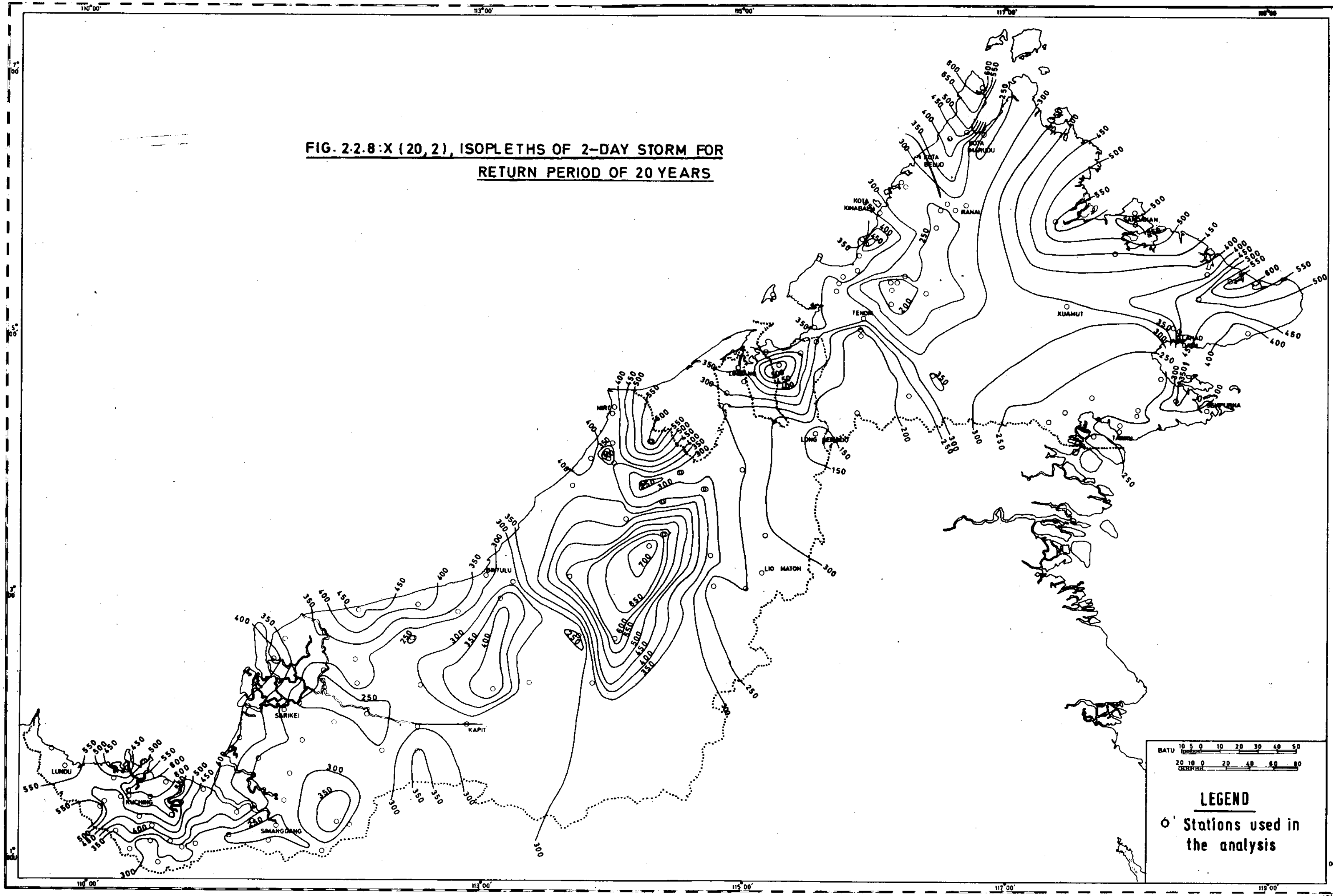


FIG. 2.2.8: X (20, 2), ISOPLETHS OF 2-DAY STORM FOR RETURN PERIOD OF 20 YEARS

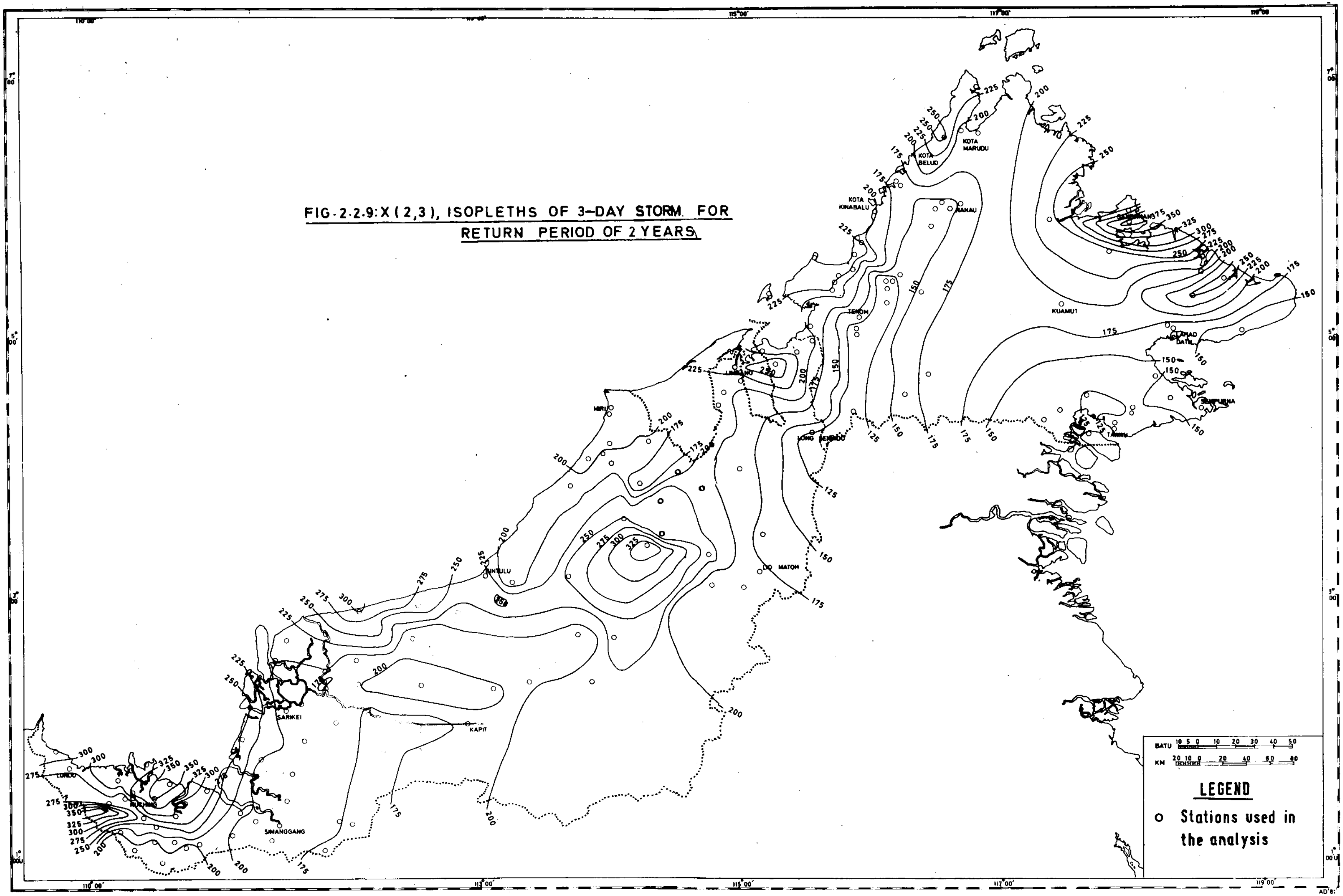
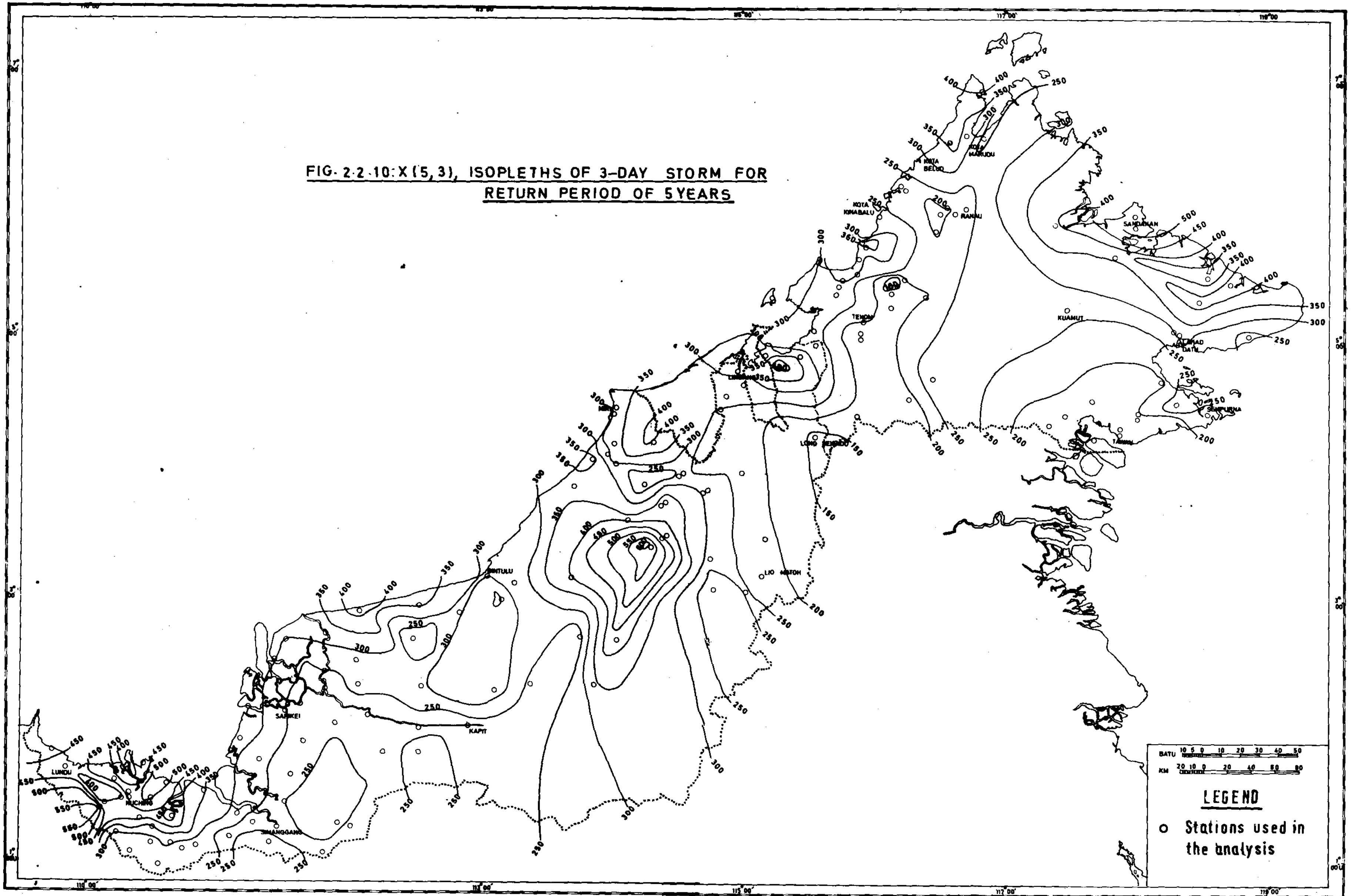


FIG-2.2.9: X(2,3), ISOPLETHS OF 3-DAY STORM FOR RETURN PERIOD OF 2 YEARS

FIG. 2.2.10: X (5, 3), ISOPLETHS OF 3-DAY STORM FOR RETURN PERIOD OF 5 YEARS



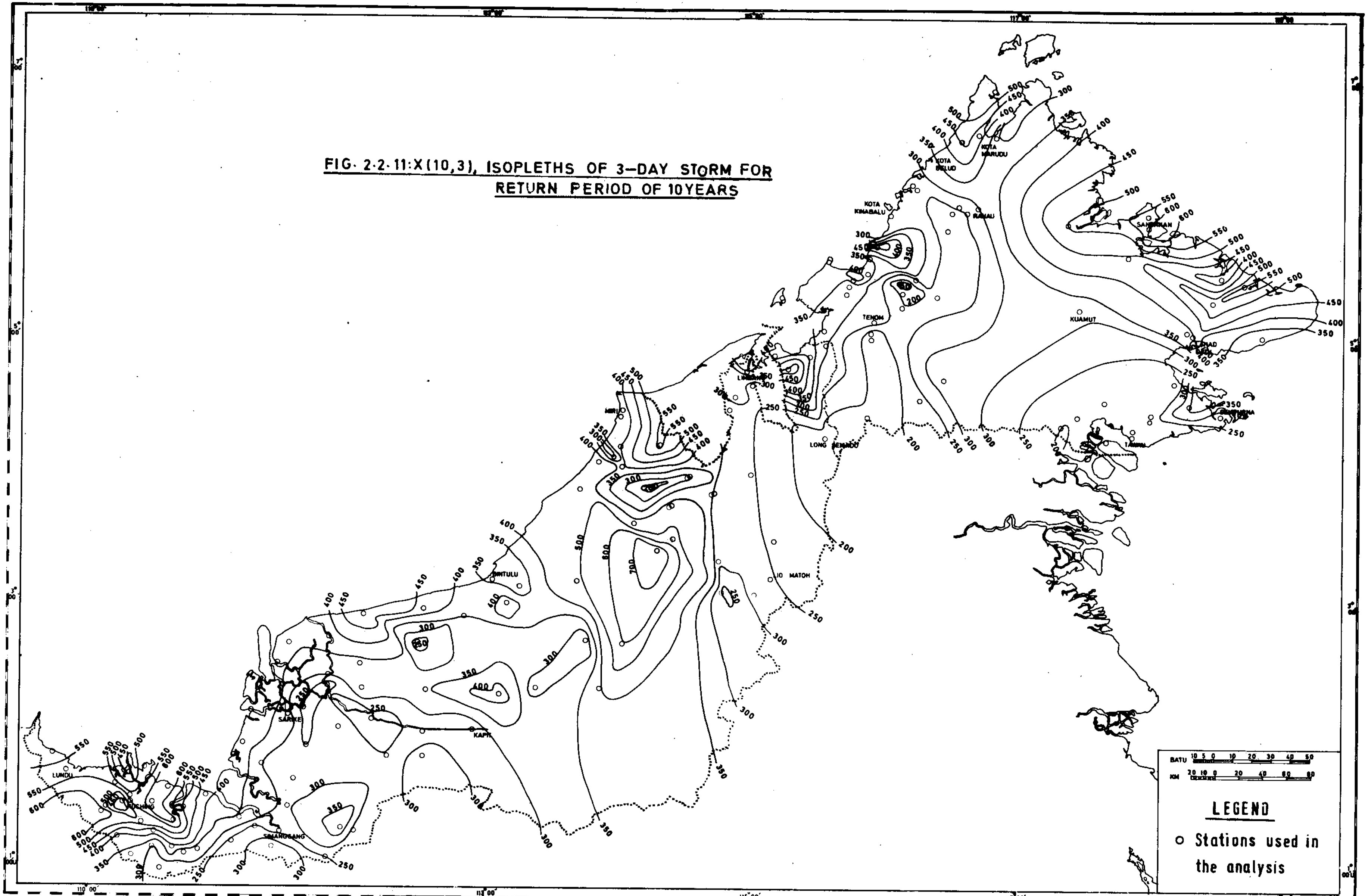


FIG. 2.2.11: X(10,3), ISOPLETHS OF 3-DAY STORM FOR RETURN PERIOD OF 10 YEARS

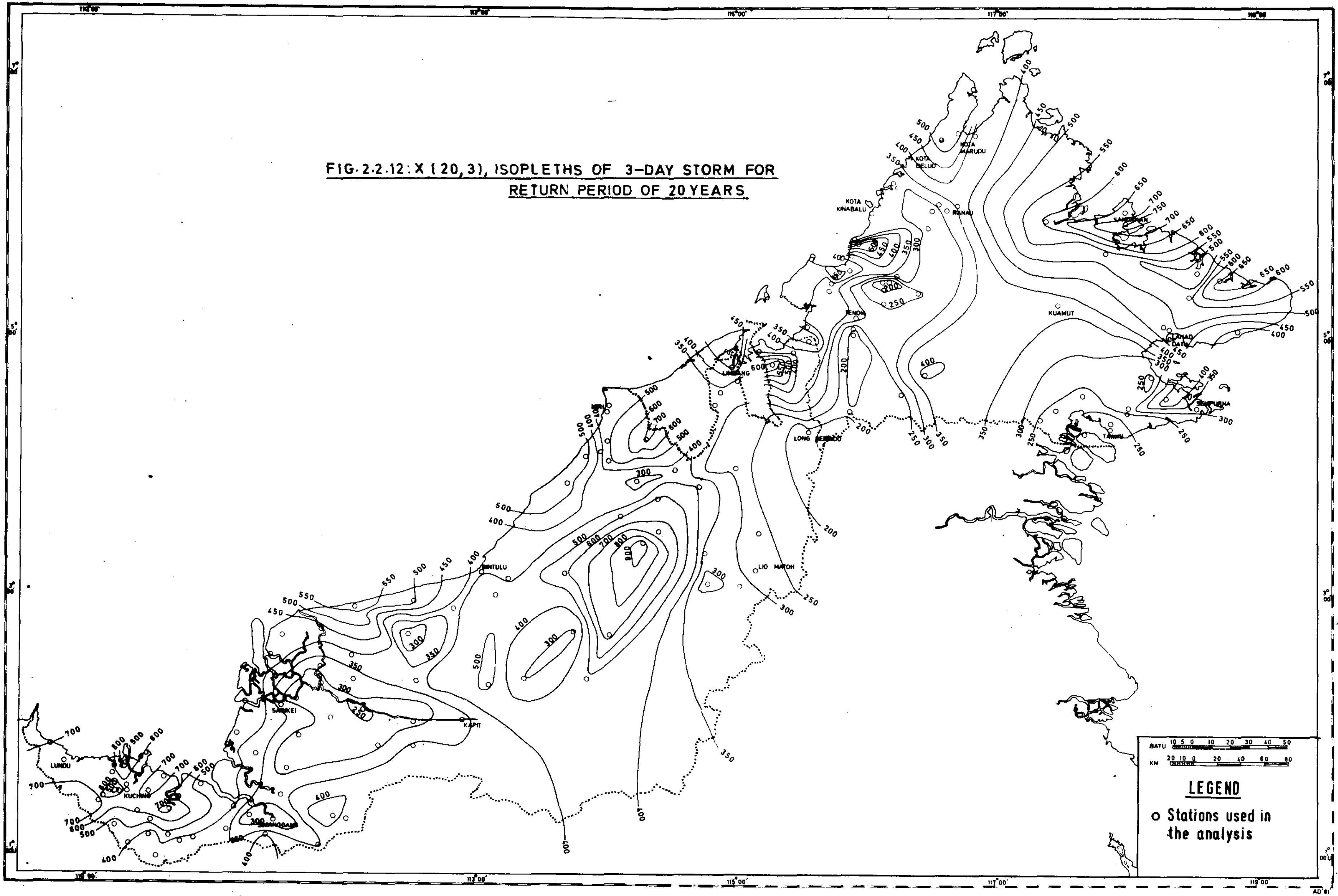


FIG. 2.2.12: X (20, 3), ISOPLETHS OF 3-DAY STORM FOR RETURN PERIOD OF 20 YEARS

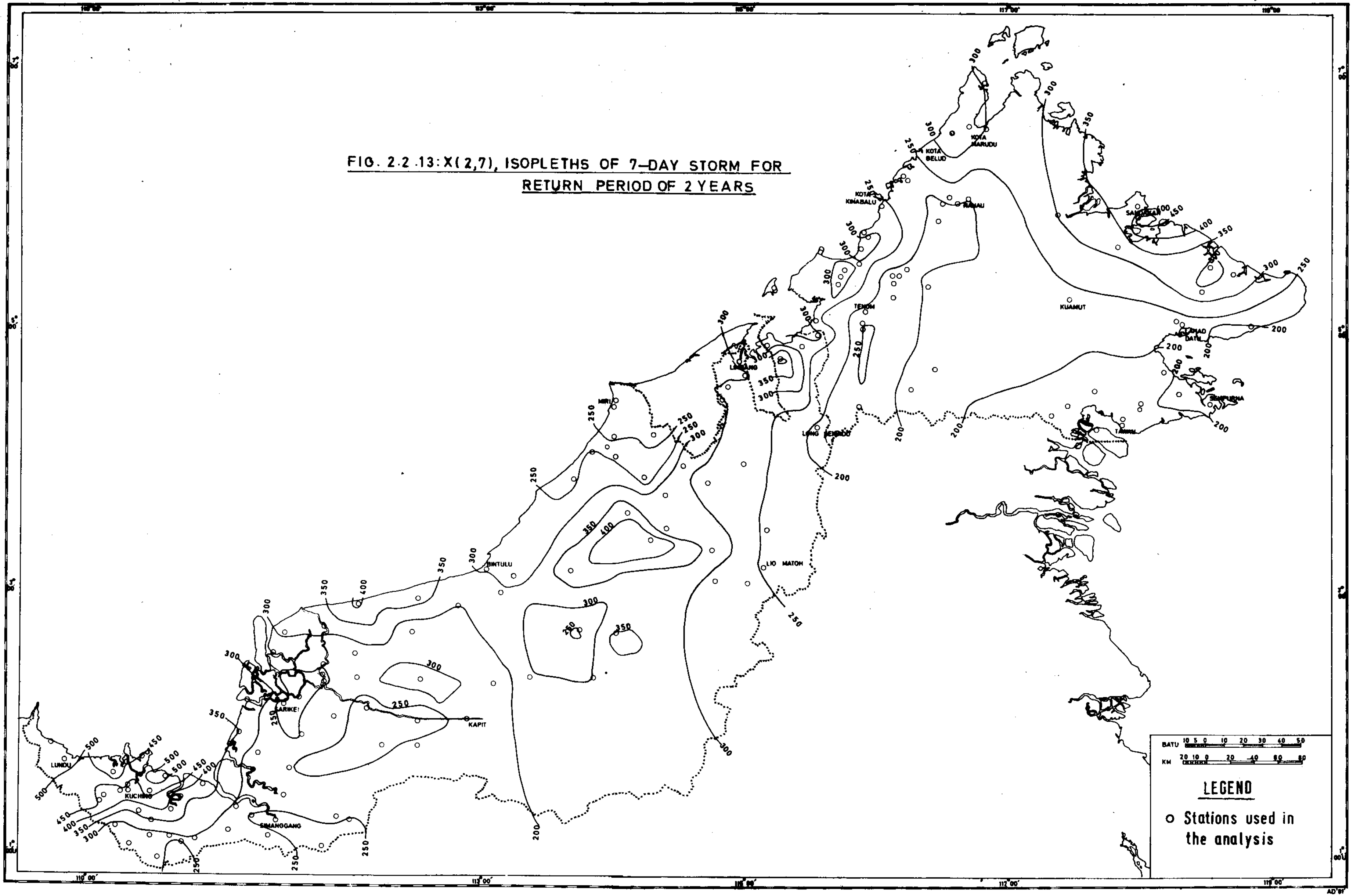


FIG. 2.2.13: X(2,7), ISOPLETHS OF 7-DAY STORM FOR RETURN PERIOD OF 2 YEARS

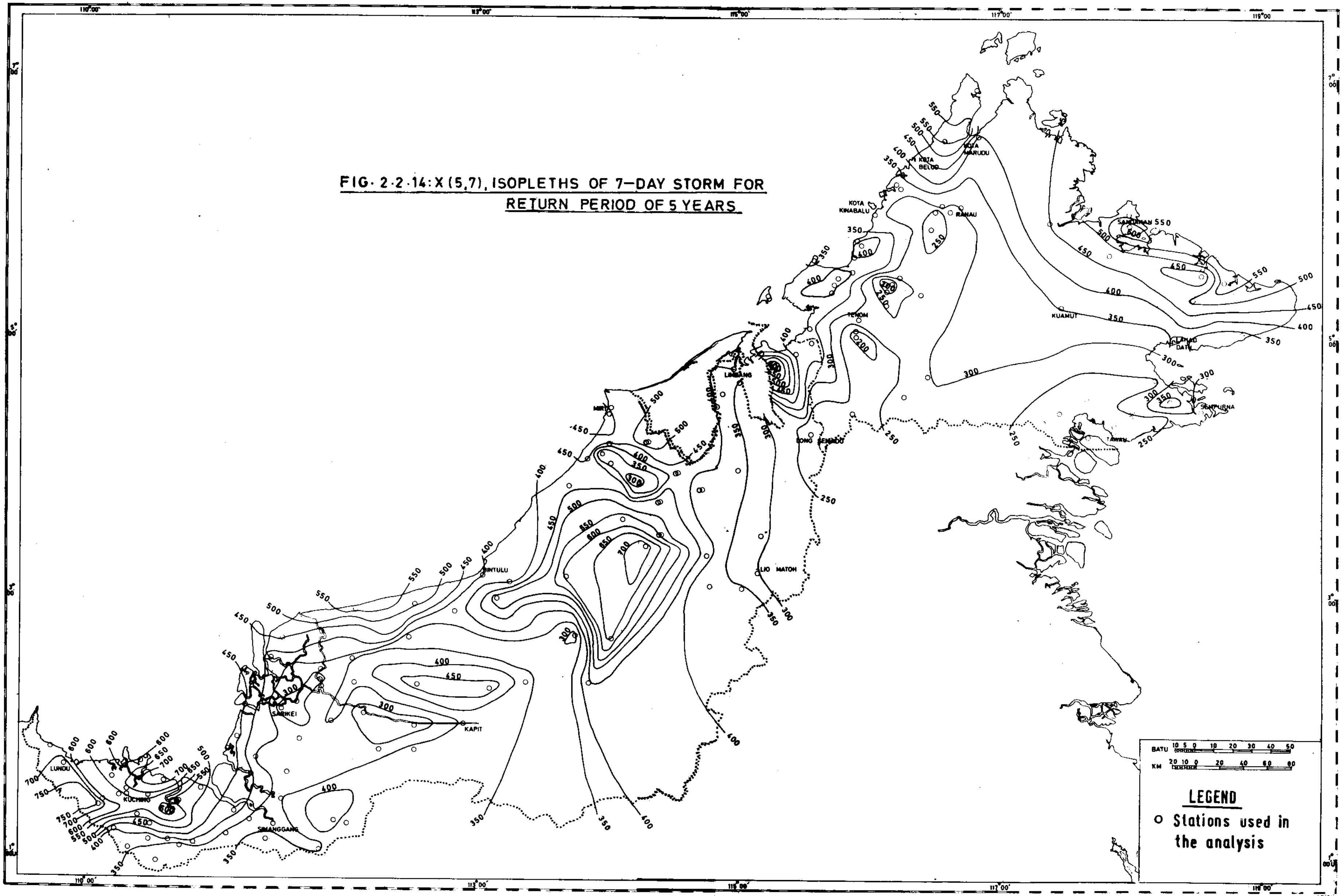


FIG. 2.2.14: X (5,7), ISOPLETHS OF 7-DAY STORM FOR RETURN PERIOD OF 5 YEARS

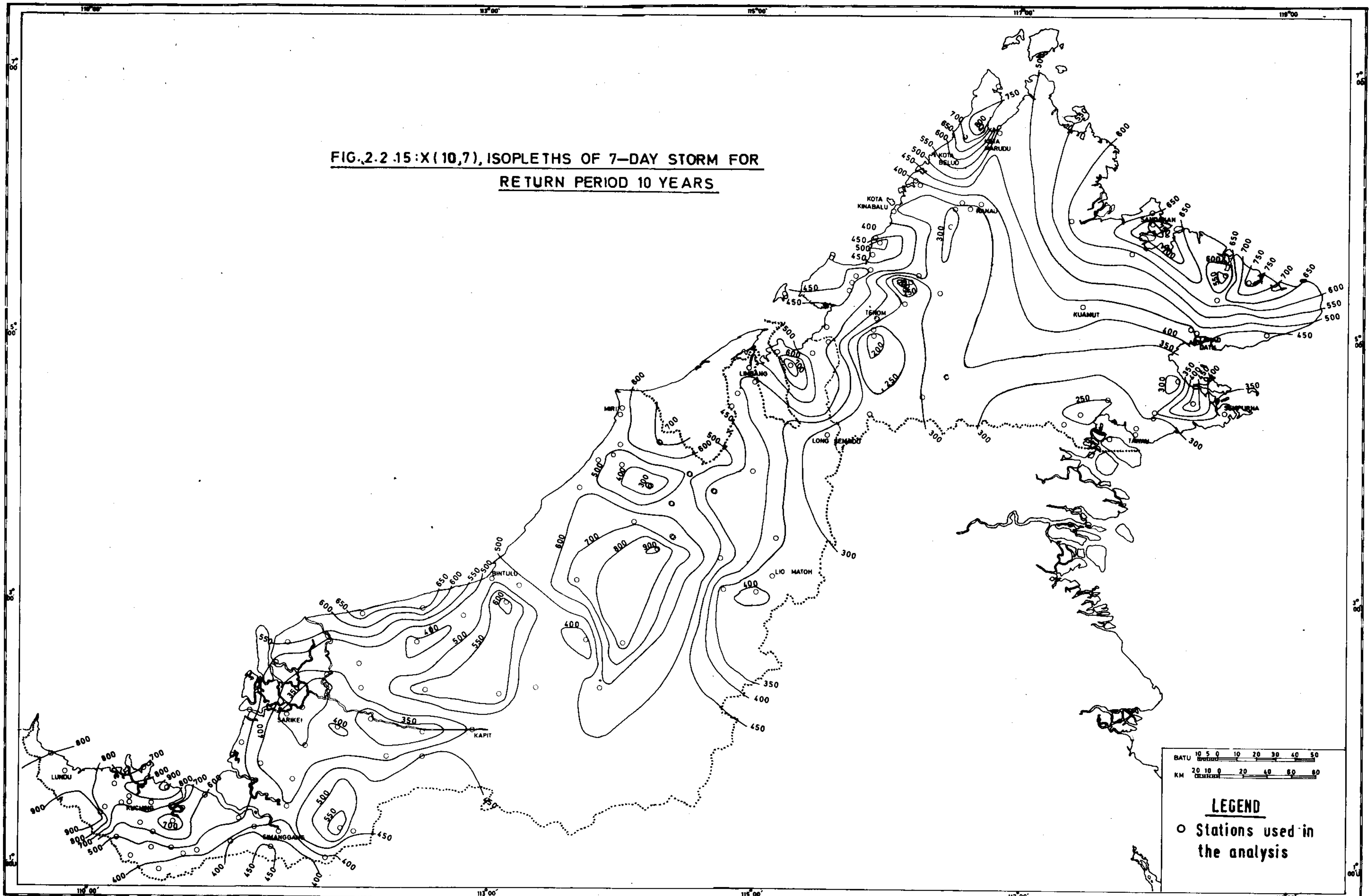


FIG. 2.2.15 : X(10,7), ISOPLETHS OF 7–DAY STORM FOR RETURN PERIOD 10 YEARS

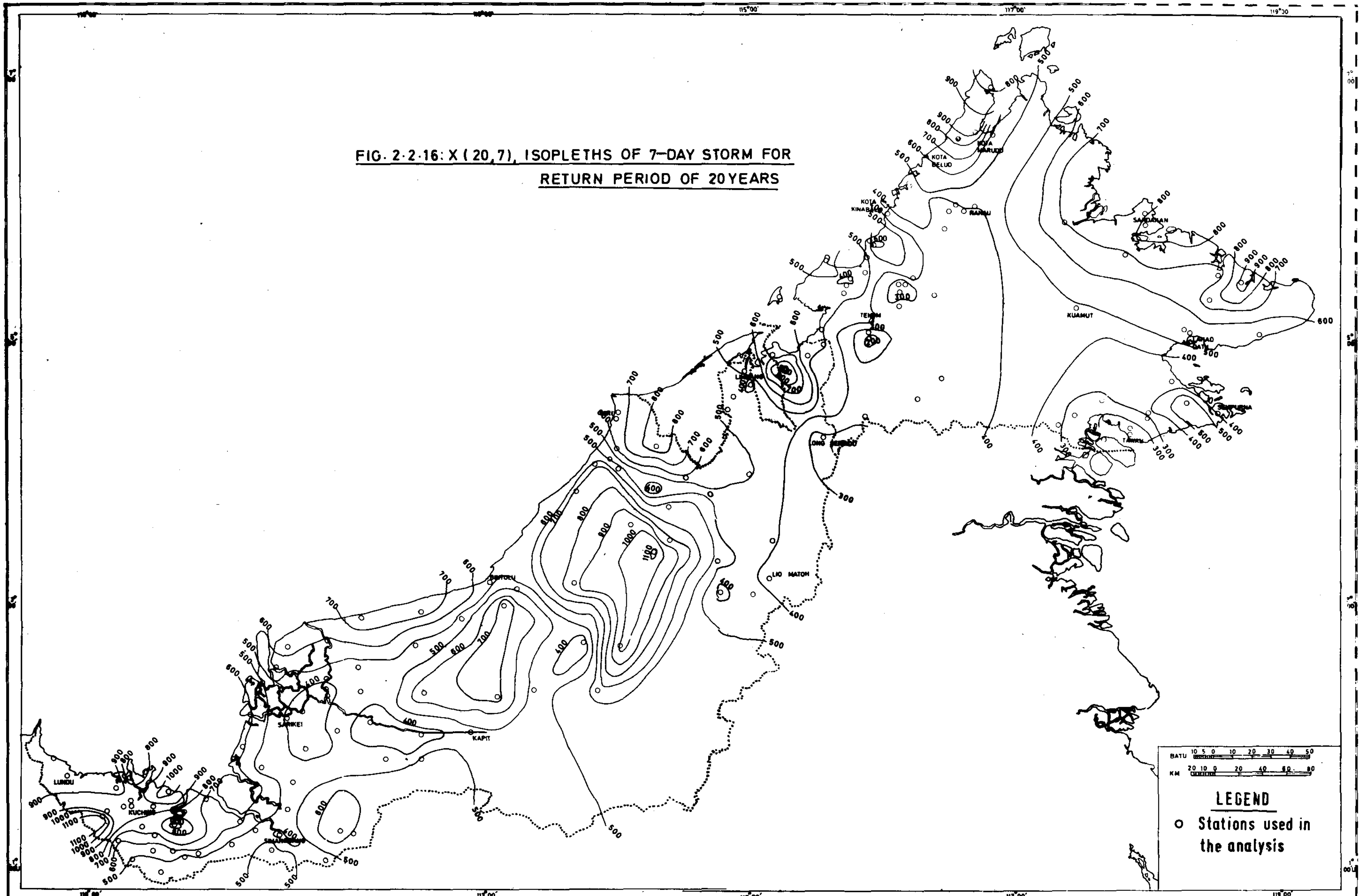


FIG. 2·2·16: X (20,7), ISOPLETHS OF 7–DAY STORM FOR RETURN PERIOD OF 20 YEARS

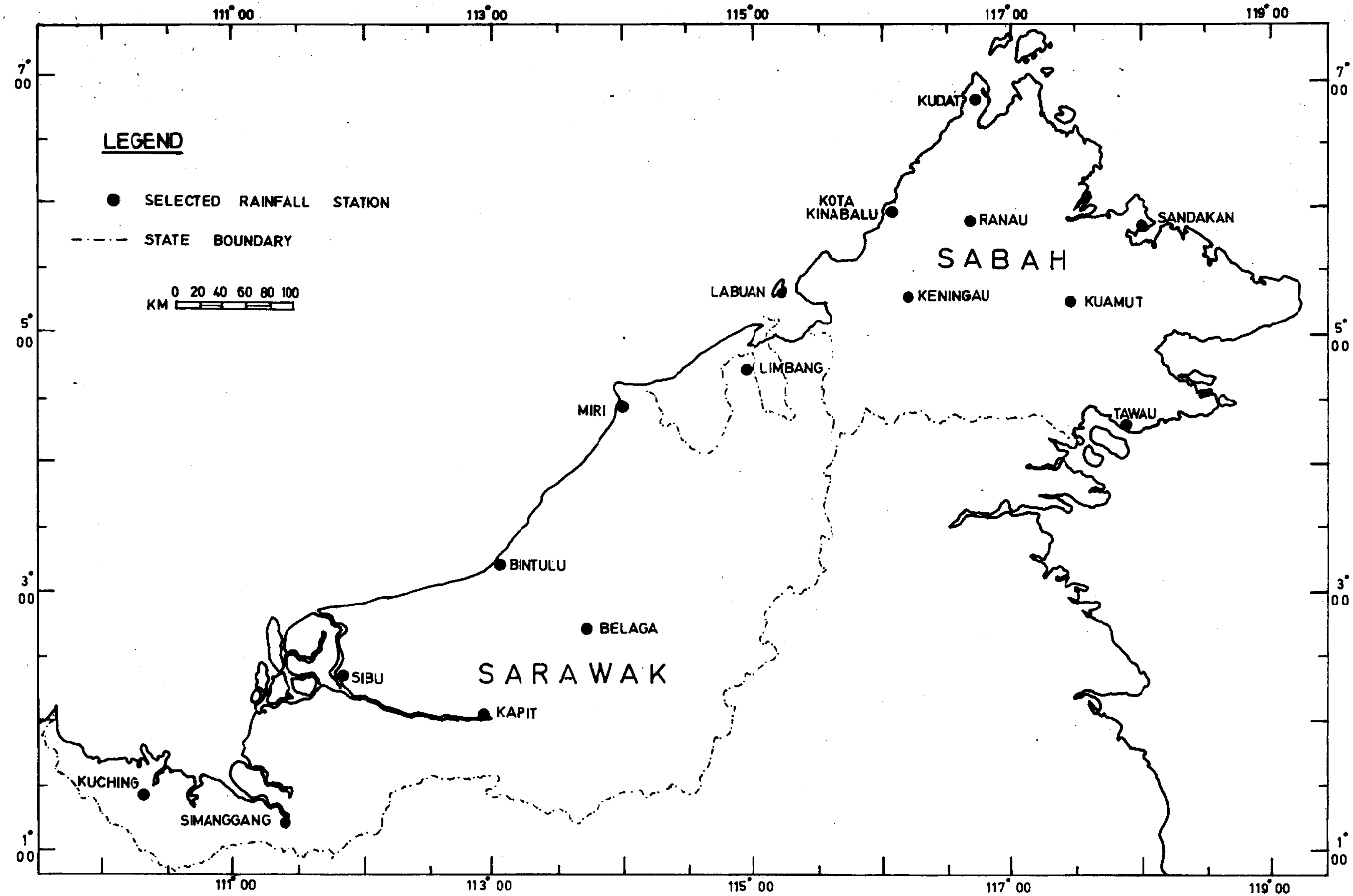


FIG. 2·3 : LOCATION OF 16 - SELECTED RAINFALL STATIONS FOR SHORT DURATION ANALYSIS

FIG. 2.3.1

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

KOTA KINABALU

(1957-1980)

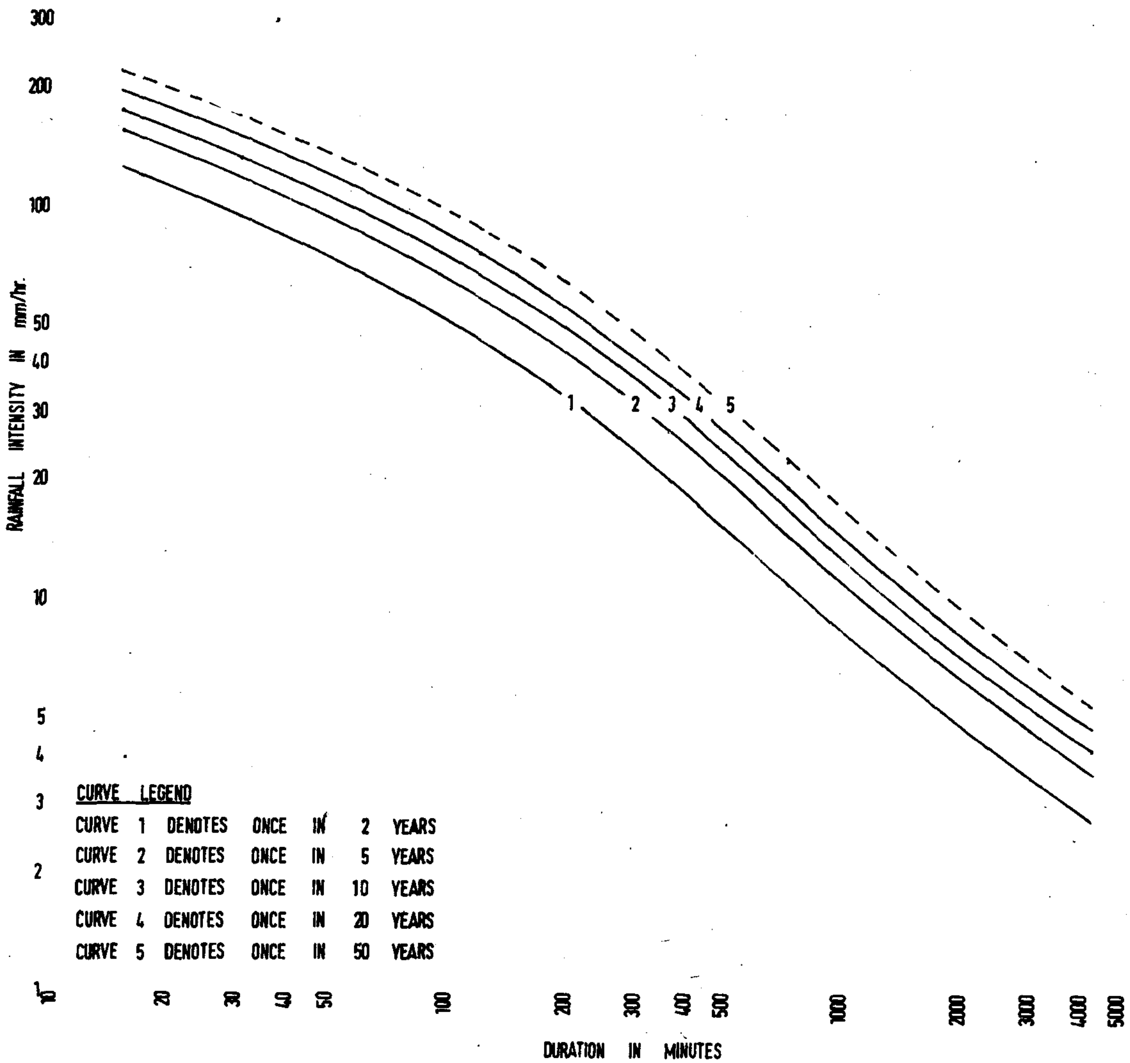


FIG. 2.3.2

RAINFALL INTENSITY — DURATION — FREQUENCY RELATION

SANDAKAN

[1957—1980]

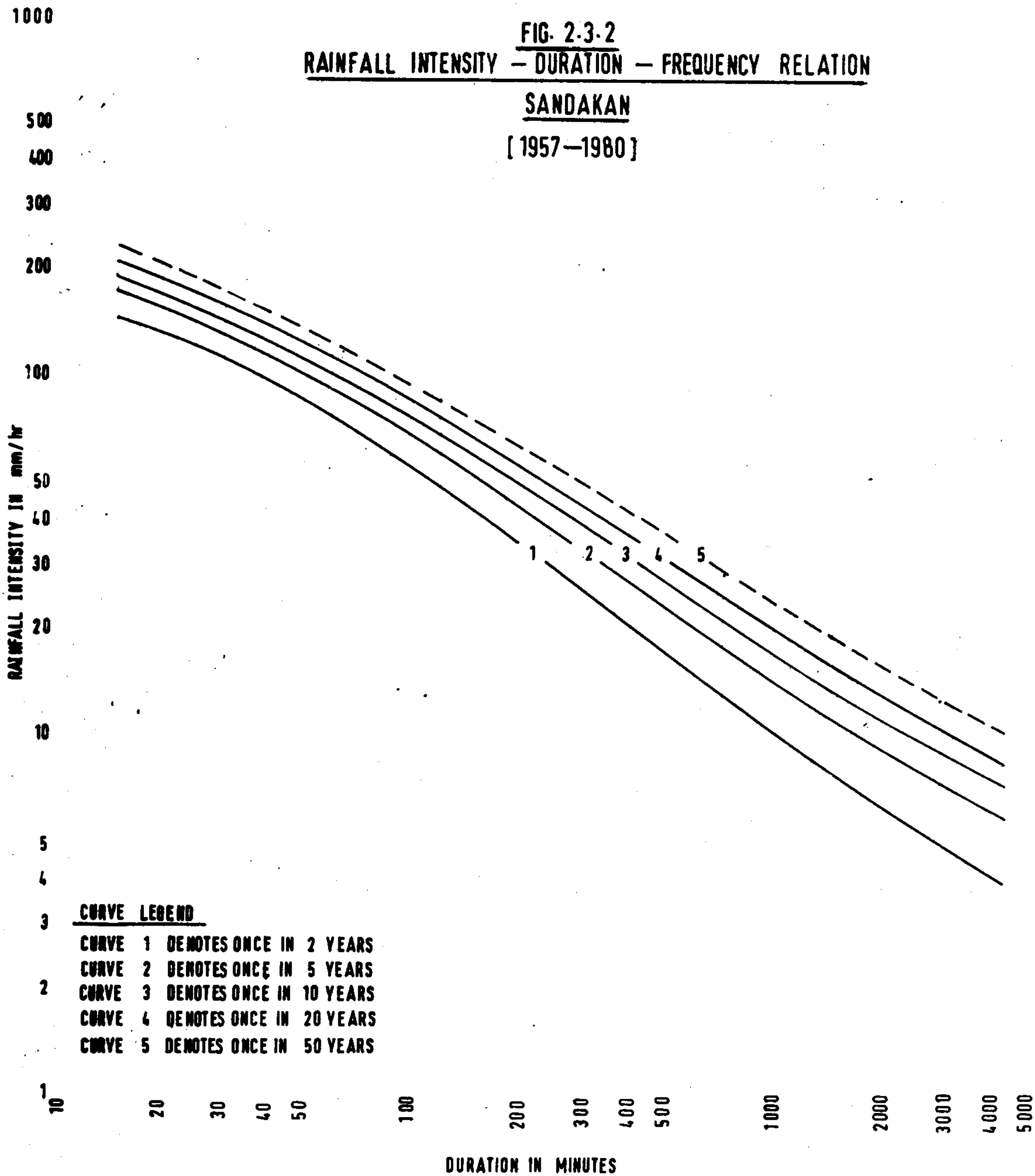


FIG. 2.3.3

RAINFALL INTENSITY - DURATION - FREQUENCY RELATION

LABUAN

[1964—1980]

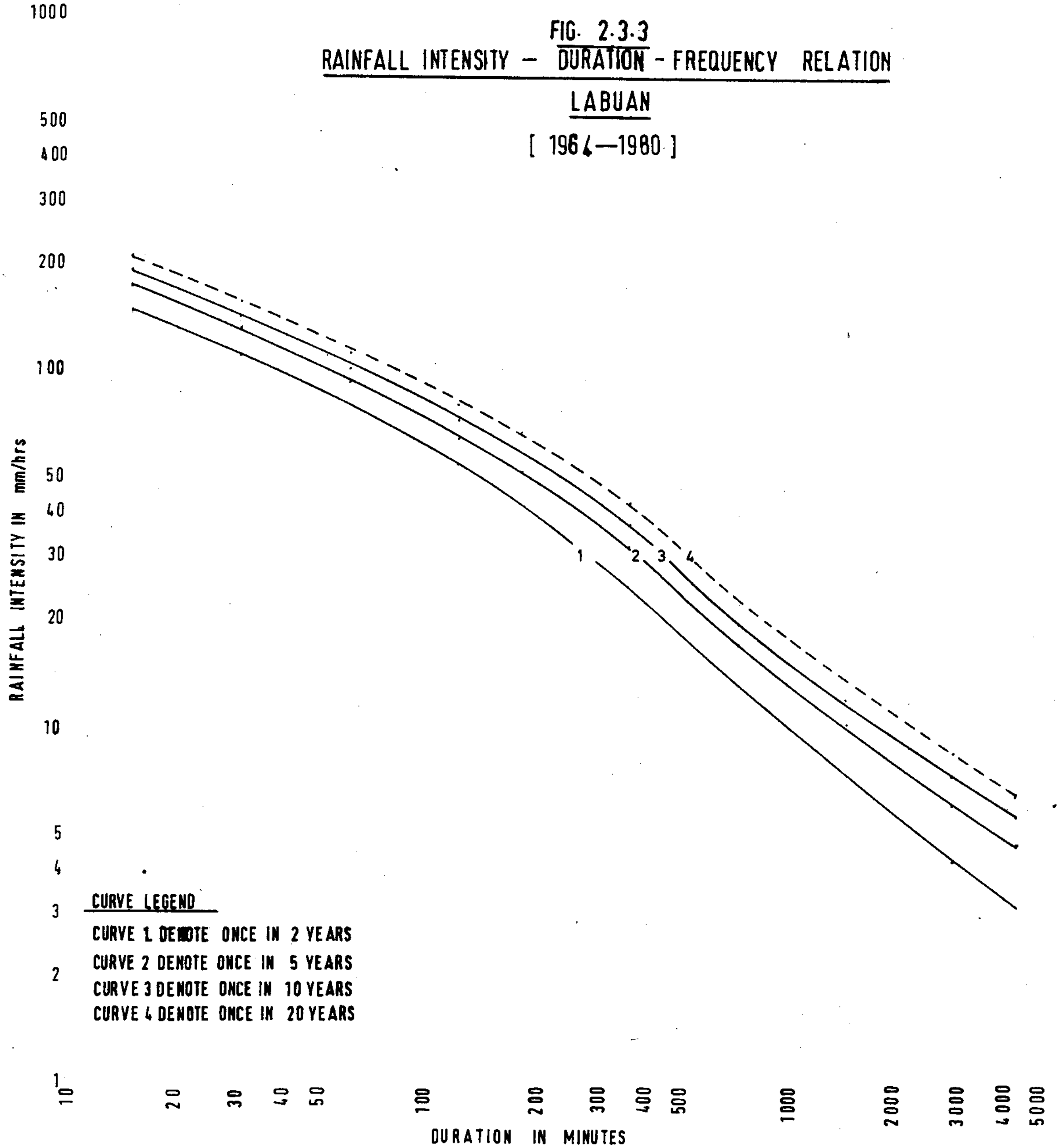


FIG. 2.3.4
RAINFALL INTENSITY - DURATION - FREQUENCY RELATION
KENINGAU
(1965 - 1980)

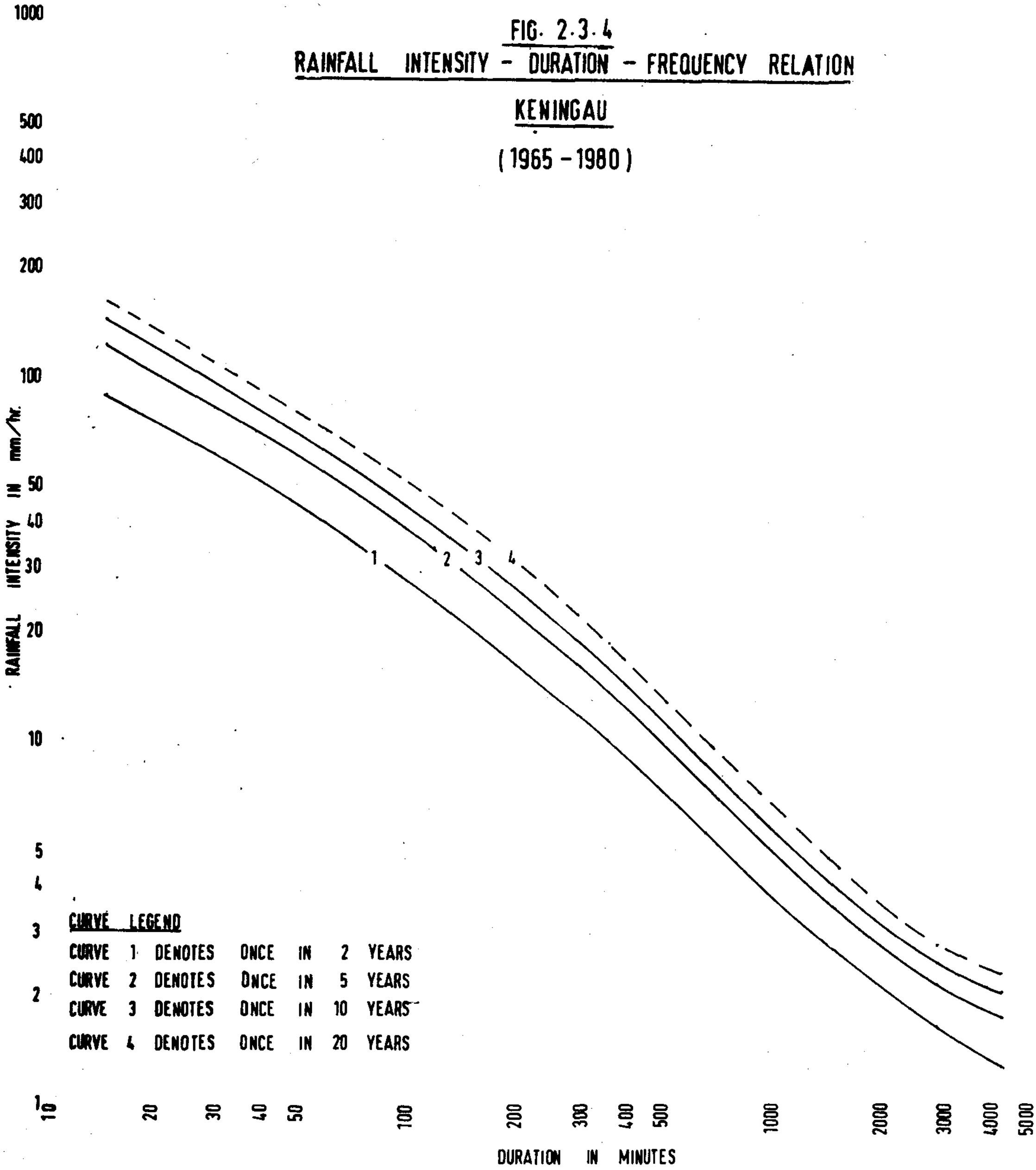


FIG. 2.3.5
RAINFALL INTENSITY - DURATION - FREQUENCY RELATION
RANAU
(1960 - 1980)

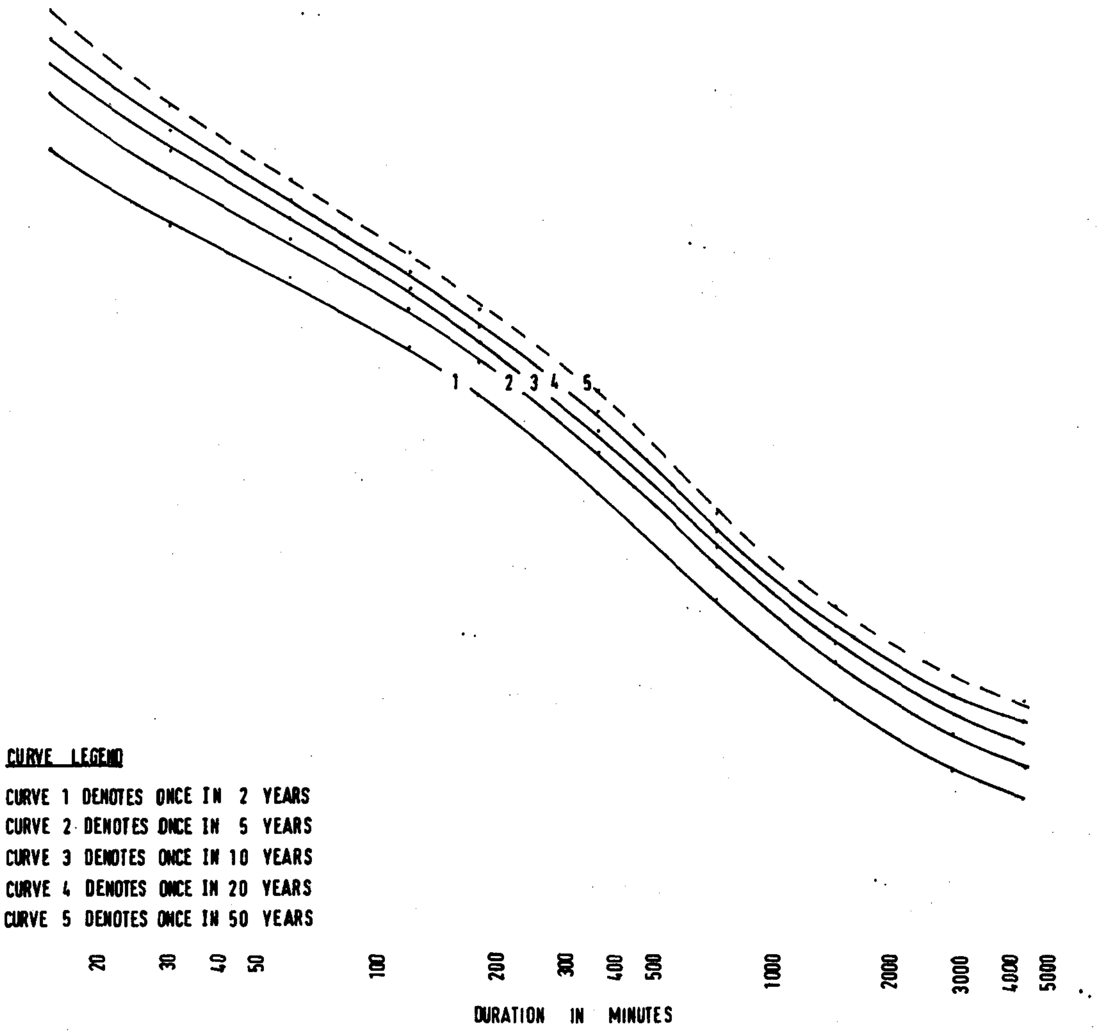


FIG. 2.3.6

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

KUDAT

(1972 – 1979)

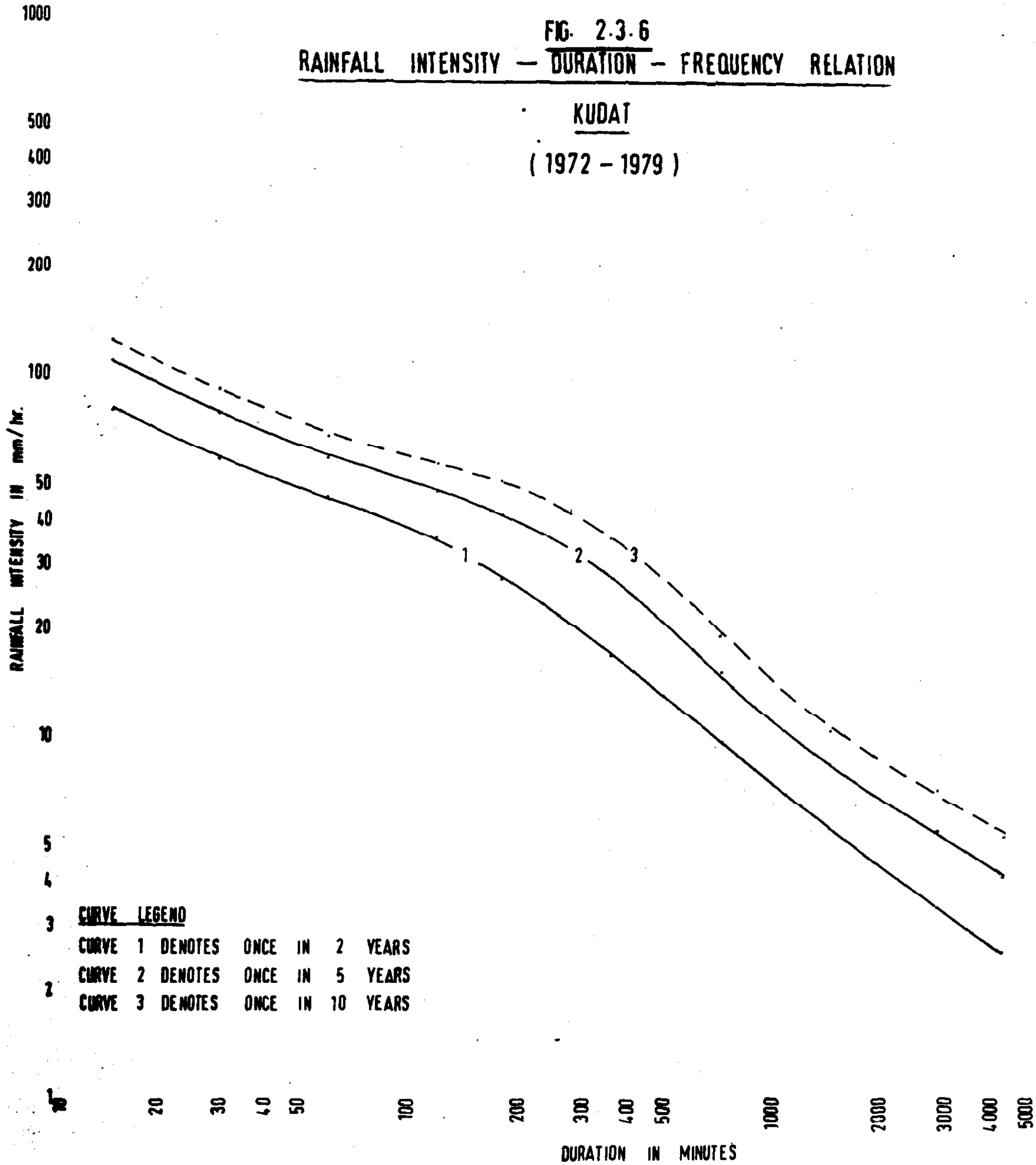


FIG. 2.3.7

RAINFALL INTENSITY - DURATION - FREQUENCY RELATION

KUAMUT

(1969 – 1980)

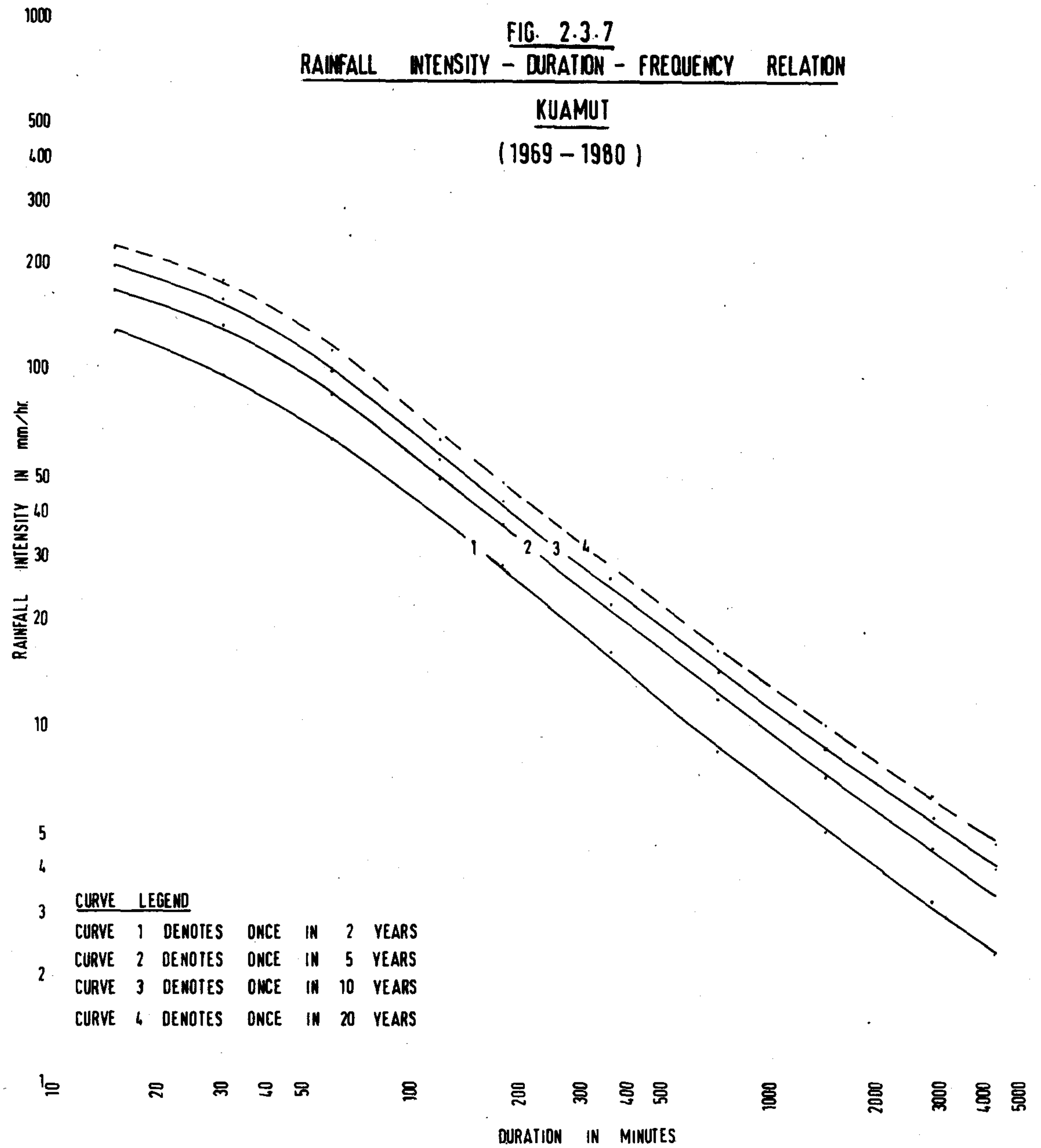


FIG. 2.3.8

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

TAWAU

(1966 – 1978)

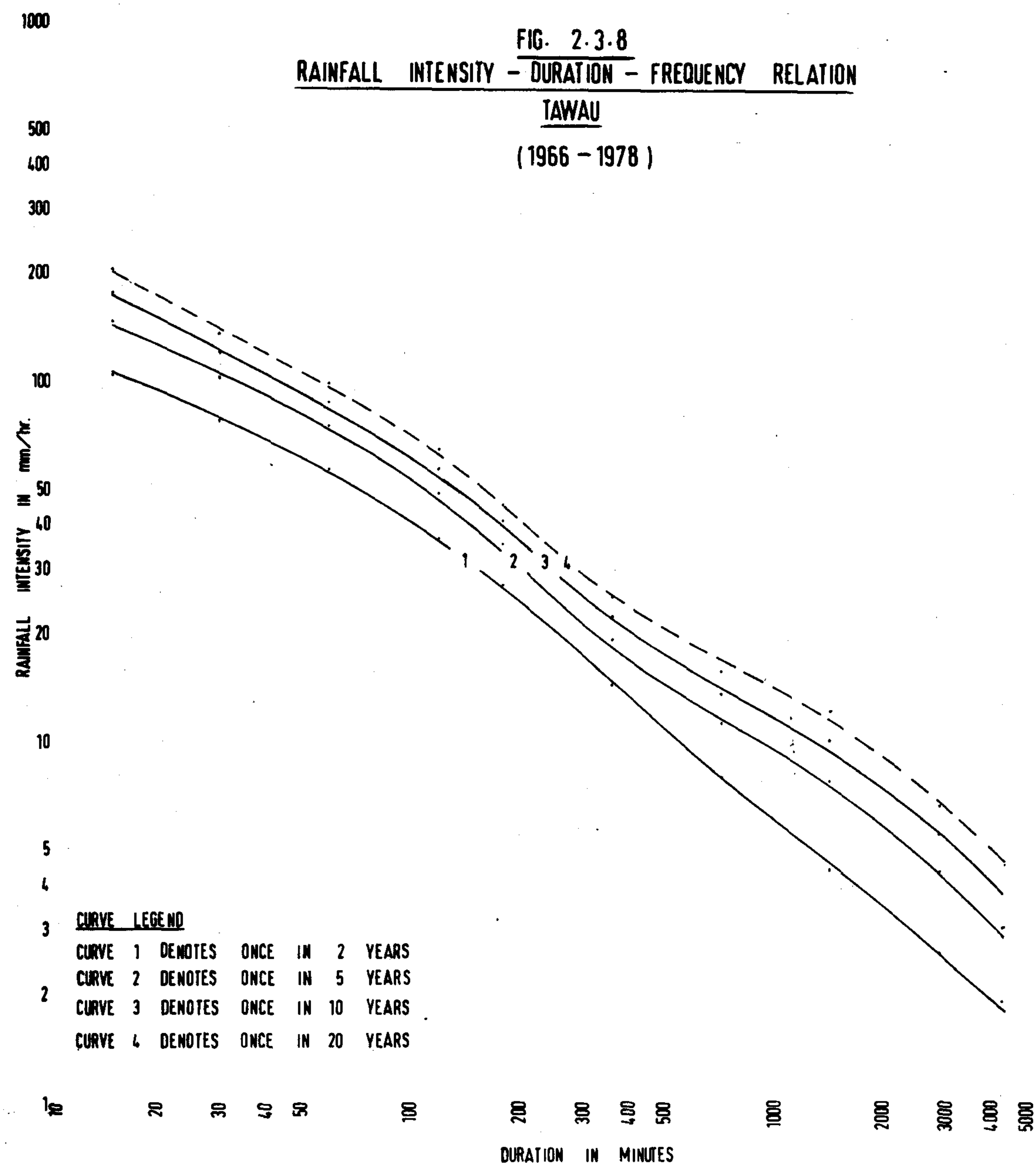


FIG. 2.3.9
RAINFALL INTENSITY – DURATION – FREQUENCY RELATION
KUCHING
(1951 – 1980)

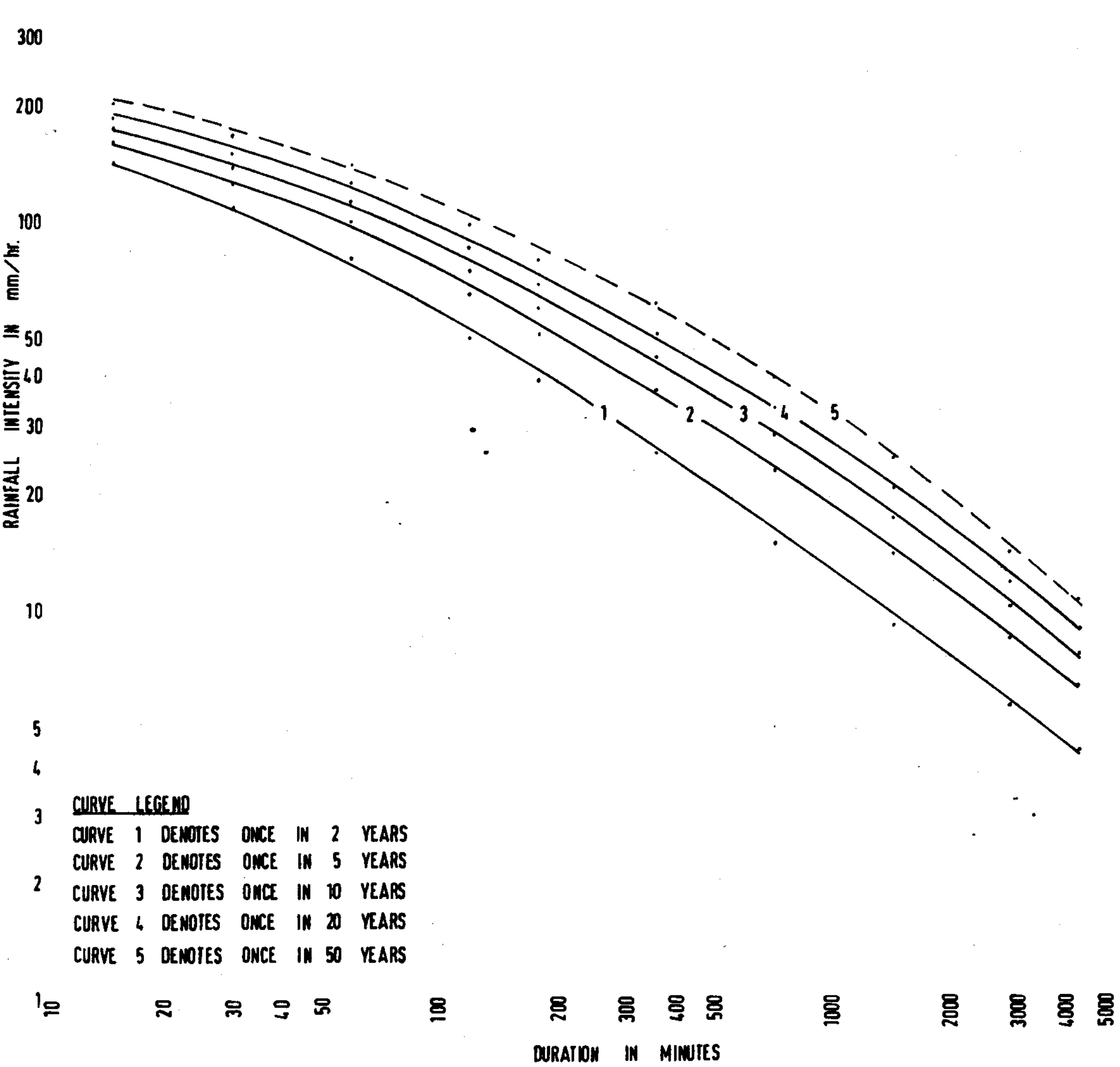


FIG. 2.3.10

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

SIBU

(1962 – 1980)

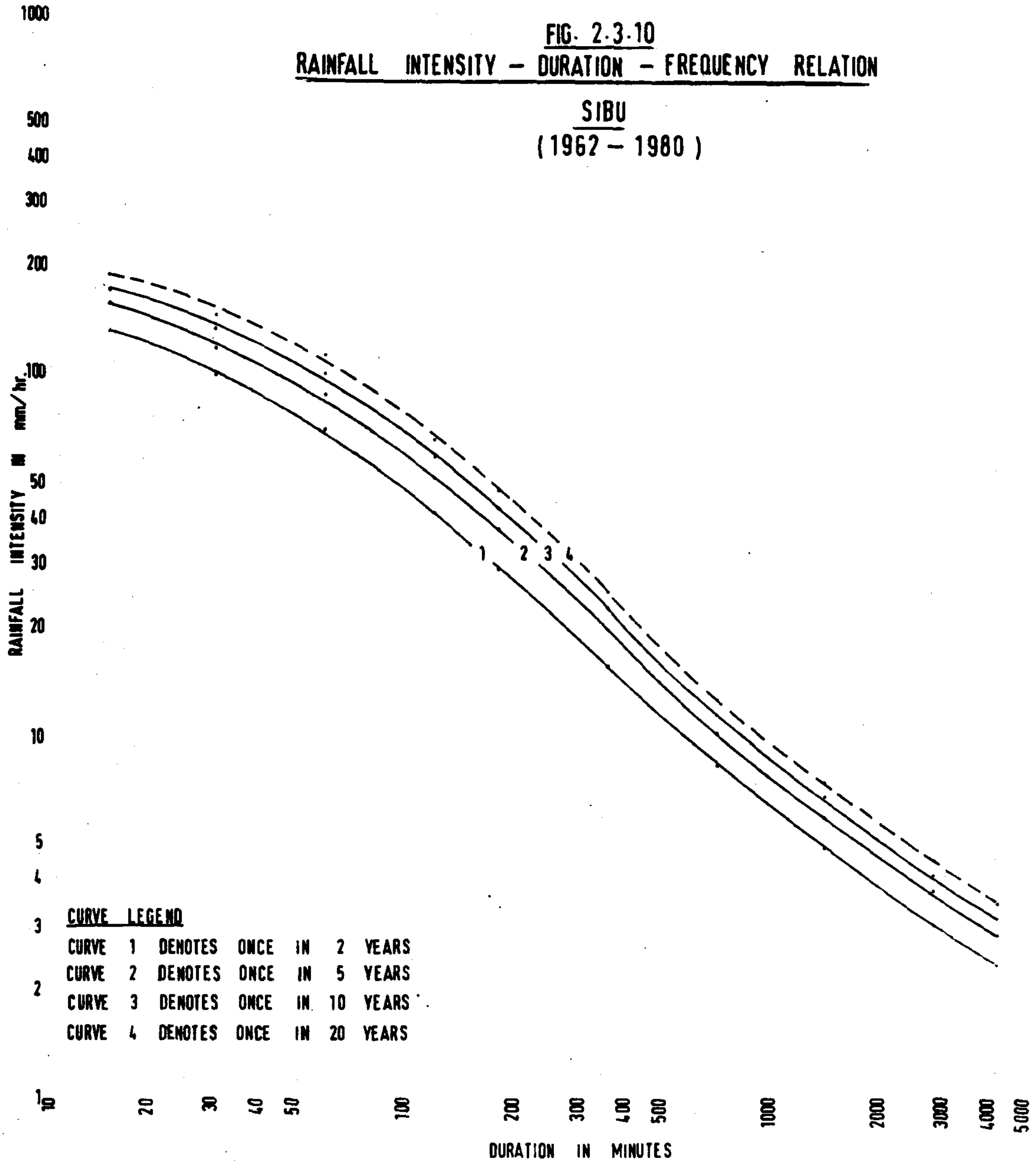


FIG. 2.3.11

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

MIRI

(1953-1980)

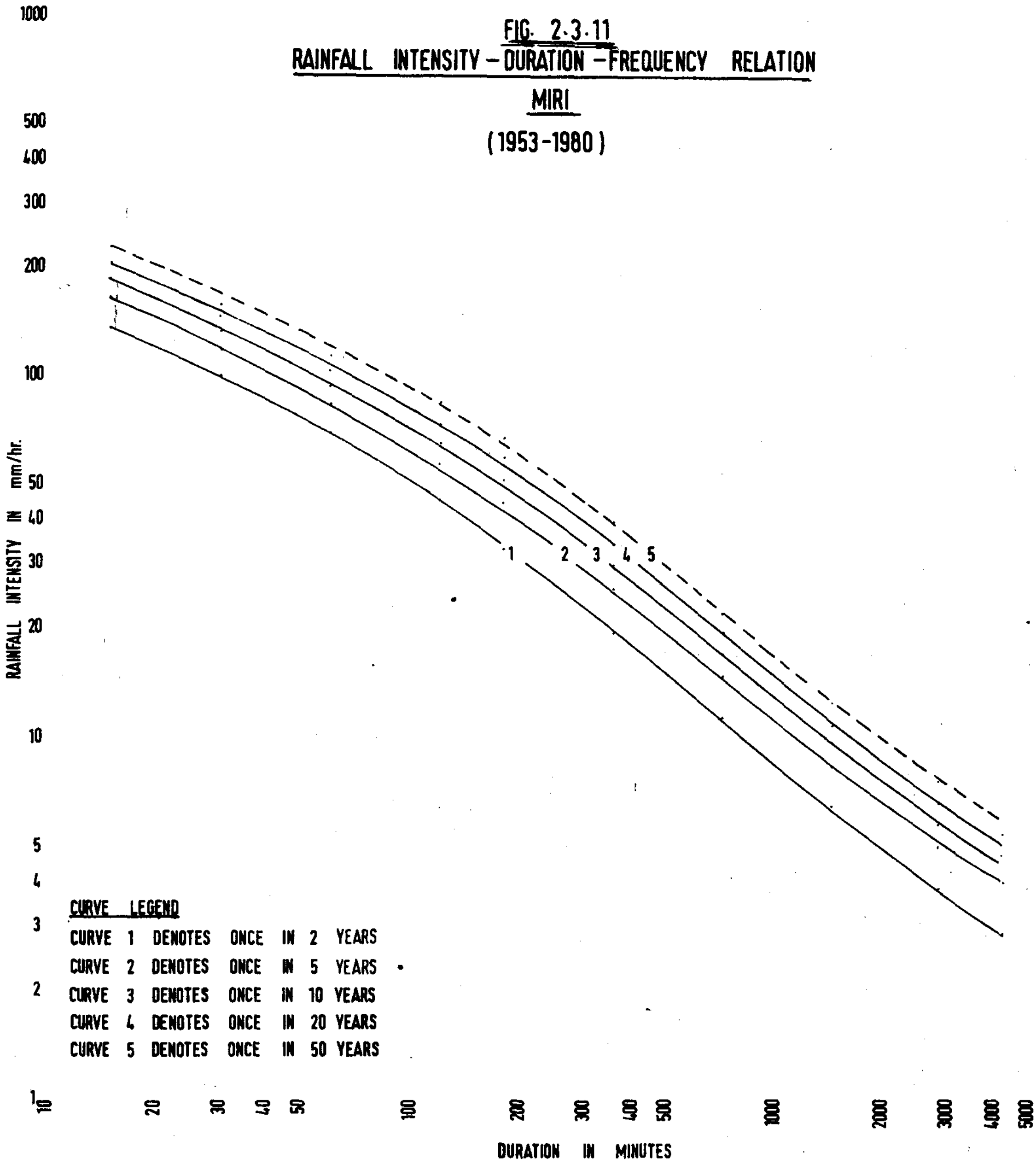


FIG. 2.3.12
RAINFALL INTENSITY — DURATION — FREQUENCY RELATION
BINTULU
[1953 – 1980]

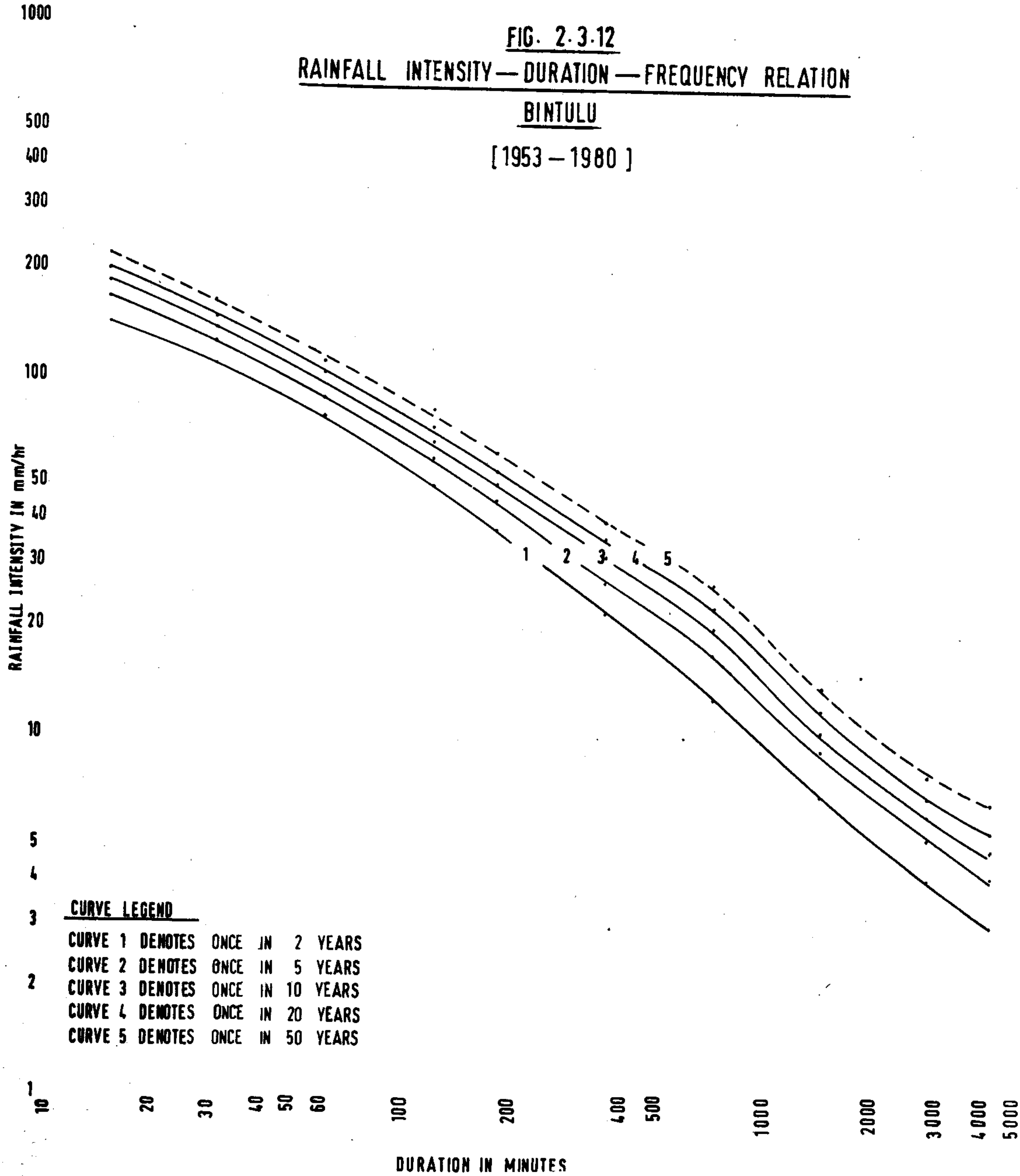


FIG. 2.3-13
RAINFALL INTENSITY – DURATION – FREQUENCY RELATION
SIMANGGANG
(1963 – 1980)

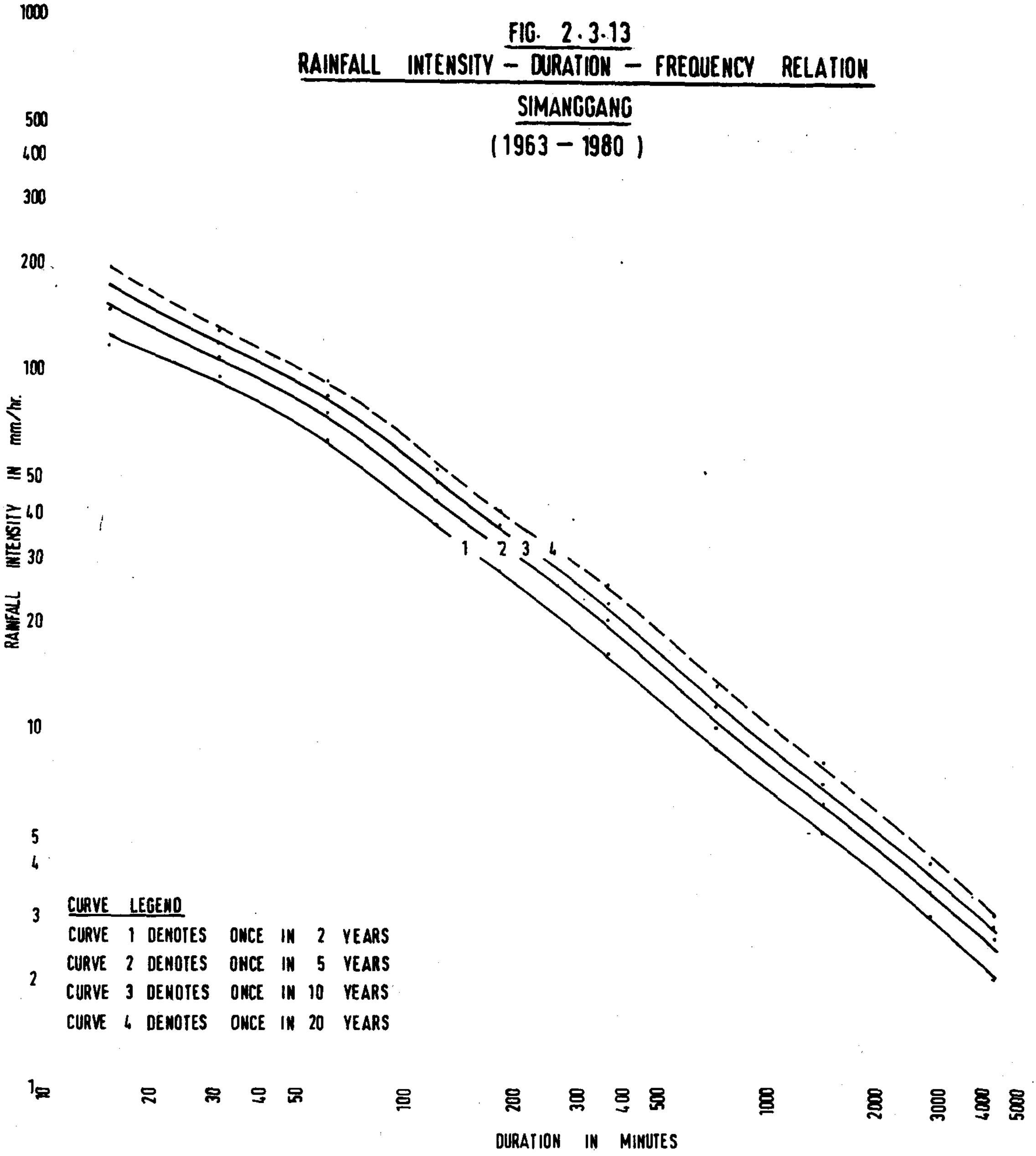


FIG. 2.3.14
RAINFALL INTENSITY - DURATION - FREQUENCY RELATION
KAPIT
(1964 - 1974)

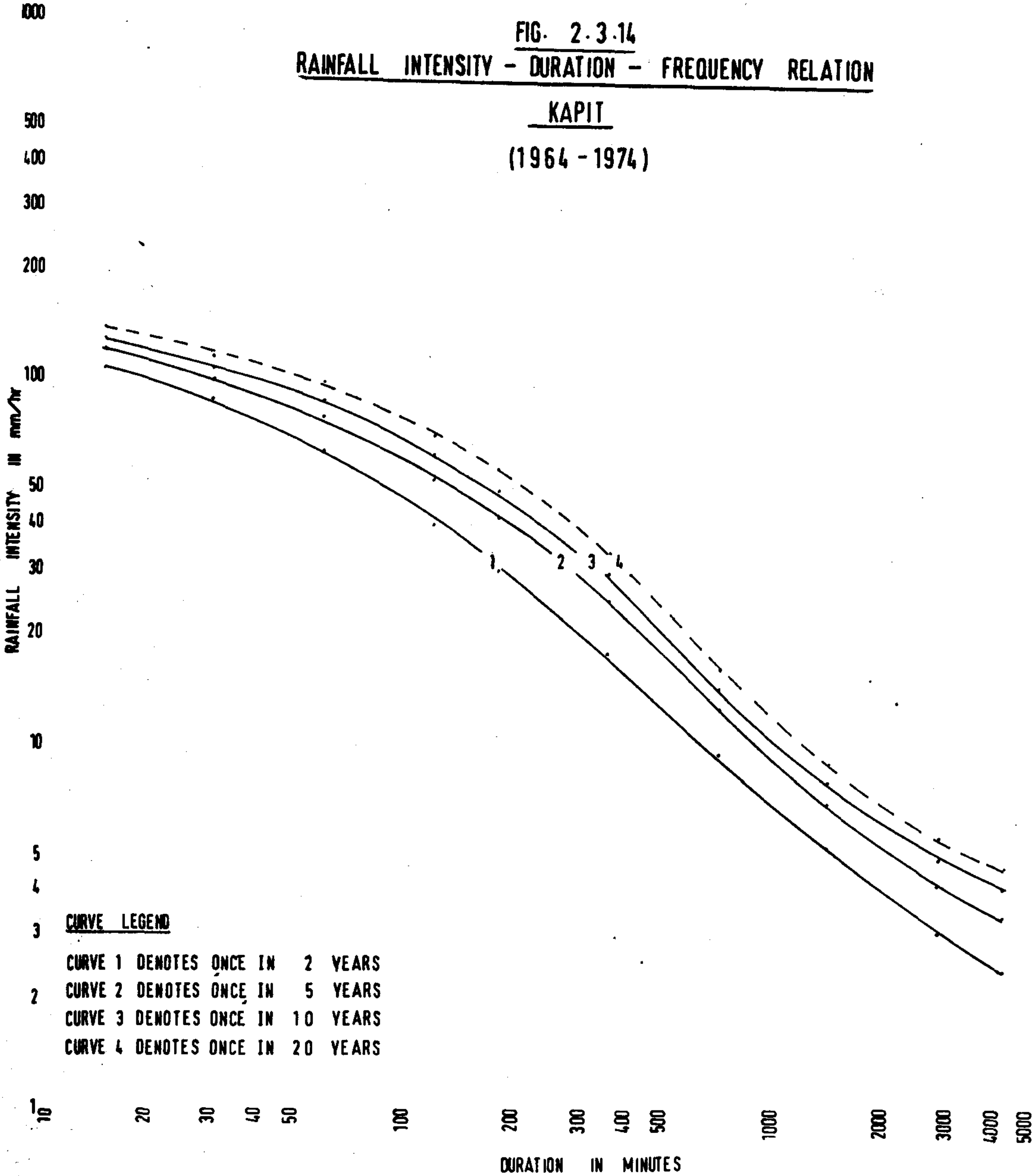


FIG. 2.3.15

RAINFALL INTENSITY - DURATION - FREQUENCY RELATION

BELAGA

(1963-1980)

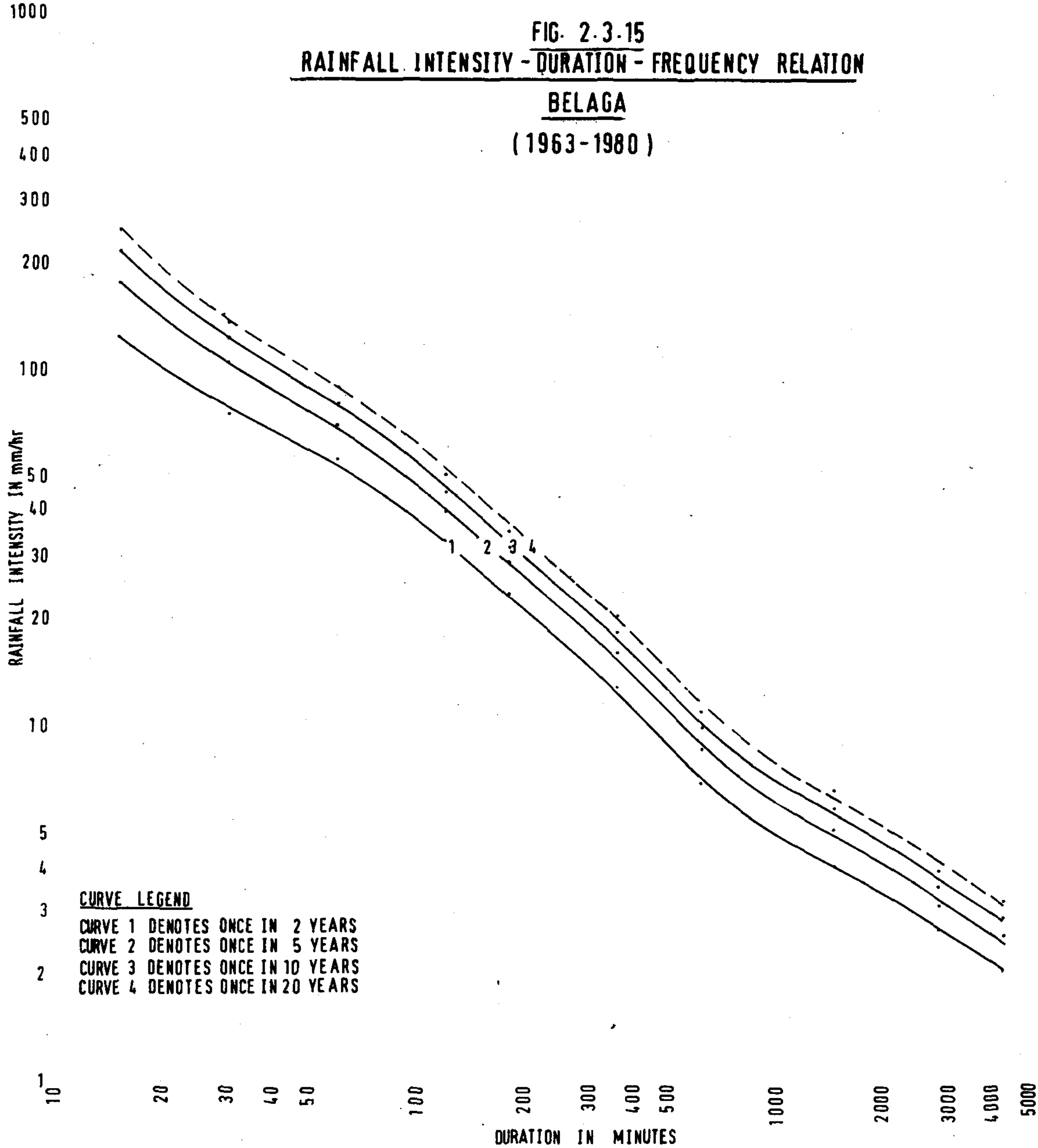
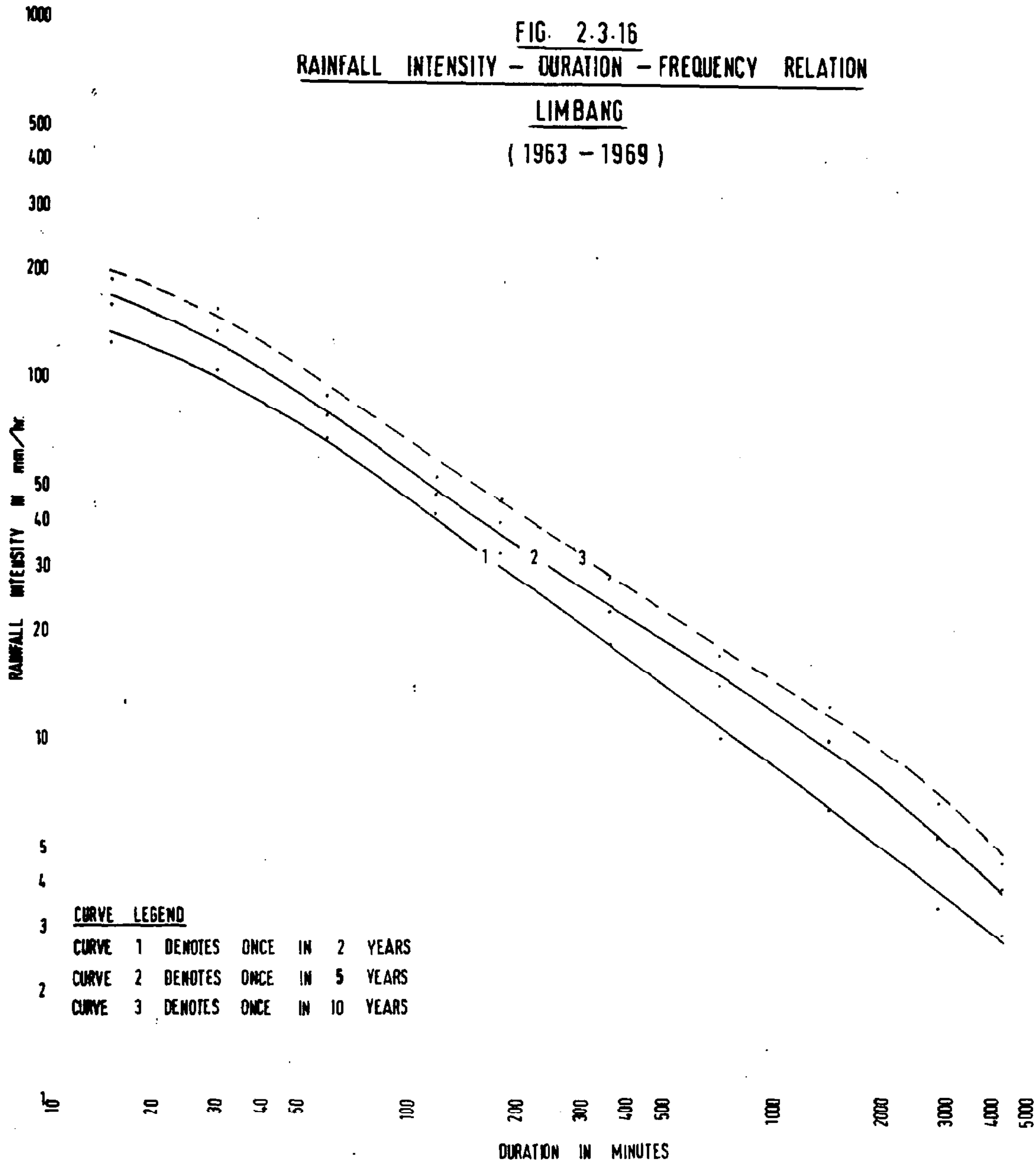


FIG. 2.3.16

RAINFALL INTENSITY – DURATION – FREQUENCY RELATION

LIMBANG

(1963 – 1969)



2.4.2 **Rainfall Depth—Duration Plotting Diagram**

2.4.2.1 *Description*

For "short duration" storm, the rainfall intensity—duration relationships have already been plotted as shown in the curves found in Component Two. Using these curves, rainfall intensities for various durations can be read off directly. However, for "long duration" storm, to estimate the depth of storm for durations other than those key values given in isopleth maps in Component Two, it is necessary to interpolate between key values. Studies (Reich, 1963; Robertson, 1963) have shown that it is possible to compute a special duration scale such that rainfall depth—duration can be plotted as straight lines between key values. For such a solution to be satisfactory, the same duration scale must be applicable to rainfall depth—duration relations of various return periods.

To derive the special duration scale, 5 year return period storm depth estimates taken from Appendix B for various storm durations were analysed. Only estimates derived from stations with more than 5 years of data were used in the analysis. For each duration (t) and period of record (n), a weighted depth was calculated for the selected stations:

$$\text{Weighted value of } X\,(5,\,t) = n\,[X\,(5,\,t)] \ldots\ldots\ldots (5).$$

The weighted values for each duration were computed, summed for all stations, and divided by the sum of all record years for the stations used to find the average 5 years return period rainfall depth for each duration:

$$\text{Average } X\,(5,\,t) = \frac{\Sigma n\,[X\,(5,\,t)]}{\Sigma n} \ldots\ldots\ldots\ldots (6)$$

The average rainfall depth—duration values for a storm with a return period of 5 years so calculated are shown in Table 2-2:

TABLE 2-2: WEIGHTED AVERAGE RAINFALL DEPTH—DURATION PATTERN FOR X (5, t)

Value	*Key*	*Interpolated*							*Key*
Duration (Day)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
Depth (MM)	290	305	320	334	347	360	372	384	396

Note that it is not necessary to interpolate rainfall depths between 1 and 3 day duration storms since they can be obtained directly from the isopleth maps. This average 5 year storm pattern was used to compute the distorted storm duration scale so that all the points calculated would plot as a straight line between the key values.

The dimensionless duration scales for the linearisation of these rainfall depth—duration values between the key values are shown in Table 2-3:

TABLE 2-3: SCALE FACTORS FOR THE CONSTRUCTION OF THE RAINFALL DEPTH—DURATION PLOTTING DIAGRAM

Duration (Day)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
Scale Factors	0.00	0.14	0.28	0.42	0.54	0.66	0.76	0.89	1.00

3.2 DISCUSSION

A sample of the rainfall depth—duration plotting diagram, constructed according to the scale factors shown in Table 2-3 is given in Appendix D. A previous study based on data from Peninsular Malaysia on the reliability of the diagram for return periods other than 5 years using 2 year and 20 year data (see H.P. 1 revised version 1982, Section 3.2) showed that errors involved are within the order of those associated with other aspects of this investigation.

PART 3—USE OF PROCEDURE

3.1 INTRODUCTION

Before using this procedure to estimate the design rainstorm, users must be fully aware of its limitations as described in earlier sections, especially for design rainstorm of short durations.

In the following sections, examples are given to illustrate the use of this procedure to estimate the design rainstorms for a given location in the States of Sabah and Sarawak.

3.2 WORKED EXAMPLES

3.2.1 Use of Isopleth Maps to Estimate "Long Duration" Rainstorm, X (T, t)

Example One: Determine the storm intensities (mm./hr.) for storms with a return period of 25 years for a location with lat. 3° 00′ N, long. 113° 00′ E, for storm durations of 1, 2, 3, 4 and 7 days. (NB: X (T, t) refers to the rainfall depth (in mm.) of a storm with a return period T years and duration t hours (short duration)/days (long duration)

1. Read values of X (T, t) for T = 2 and T = 20 and for t = 1, 2, 3 and 7 days:

X (2, 1) = 156 mm. (Fig. 2.2.1)
X (20, 1) = 278 mm. (Fig. 2.2.4)
X (2, 2) = 185 mm. (Fig. 2.2.5)
X (20, 2) = 315 mm. (Fig. 2.2.8)
X (2, 3) = 235 mm. (Fig. 2.2.9)
X (20, 3) = 410 mm. (Fig. 2.2.12)
X (2, 7) = 320 mm. (Fig. 2.2.13)
X (20, 7) = 500 mm. (Fig. 2.2.16)

2. Set a suitable ordinate scale on the rainfall depth—return period plotting diagram and plot the eight values of X (T, t) as shown in Fig. Ex-1 (*a*).

3. Draw straight lines between points representing the same duration.

4. Read off the rainfall depth values from Fig. Ex—1 (*a*) corresponding to a return period of 25 years:

X (25, 1) = 290 mm.
X (25, 2) = 330 mm.
X (25, 3) = 425 mm.
X (25, 7) = 518 mm.

5. Set a suitable ordinate scale on the rainfall depth—duration plotting diagram and plot the two values X (25, 3) and X (25, 7) above as shown in Fig. EX-1 (*b*).

6. Draw a straight line joining the two points.

7. Read off the rainfall depth from Fig. EX-1 (*b*) corresponding to a duration of 4 days:

X (25, 4) = 425 mm.

8. The results are:

X (25, 1) = 290 mm.
X (25, 2) = 330 mm.
X (25, 3) = 425 mm.
X (25, 4) = 452 mm.
X (25, 7) = 518 mm.

3.2.2. Use of Rainfall Intensity—Duration—Frequency Curves to Estimate "Short Duration" Rainstorms

Example Two: Determine the storm intensities at Gum Gum, Sabah lat. 5° 55′ N and long. 117° 55′ E for return period of 25 years and storm durations of 2, 4 and 6 hours.

1. Refer to the map in Fig. 2-3 and select an appropriate station which best represents the location concerned. In this case the station at Sandakan is selected.

2. From Fig. 2.3.2 which is the Rainfall intensity—Duration—Frequency Curve for Sandakan, values of X (T, t) in *mm./hr.* for T = 20, 50 years and t = 2, 4 and 6 hours are read:

X (20, 2) = 76 mm./hr.
X (50, 2) = 85 mm./hr.
X (20, 4) = 50 mm./hr.
X (50, 4) = 57 mm./hr.
X (20, 6) = 38 mm./hr.
X (50, 6) = 44 mm./hr.

3. Set a suitable ordinate scale on the rainfall intensity—return period plotting diagram and plot the six values of X (T, t) as shown in Fig. EX-2.

4. Draw straight lines between points representing the same duration.

5. Reading off the rainfall intensity values from Fig. EX-2 corresponding to a return period of 25 years gives the following results:

$$X\,(25, 2) = 79 \text{ mm./hr.}$$
$$X\,(25, 4) = 52 \text{ mm./hr.}$$
$$X\,(25, 6) = 40 \text{ mm./hr.}$$

FIG EX-1(a) EXAMPLE 1. RAINFALL DEPTH—RETURN PERIOD PLOTTING DIAGRAM FOR CONSTANT STORM DURATION

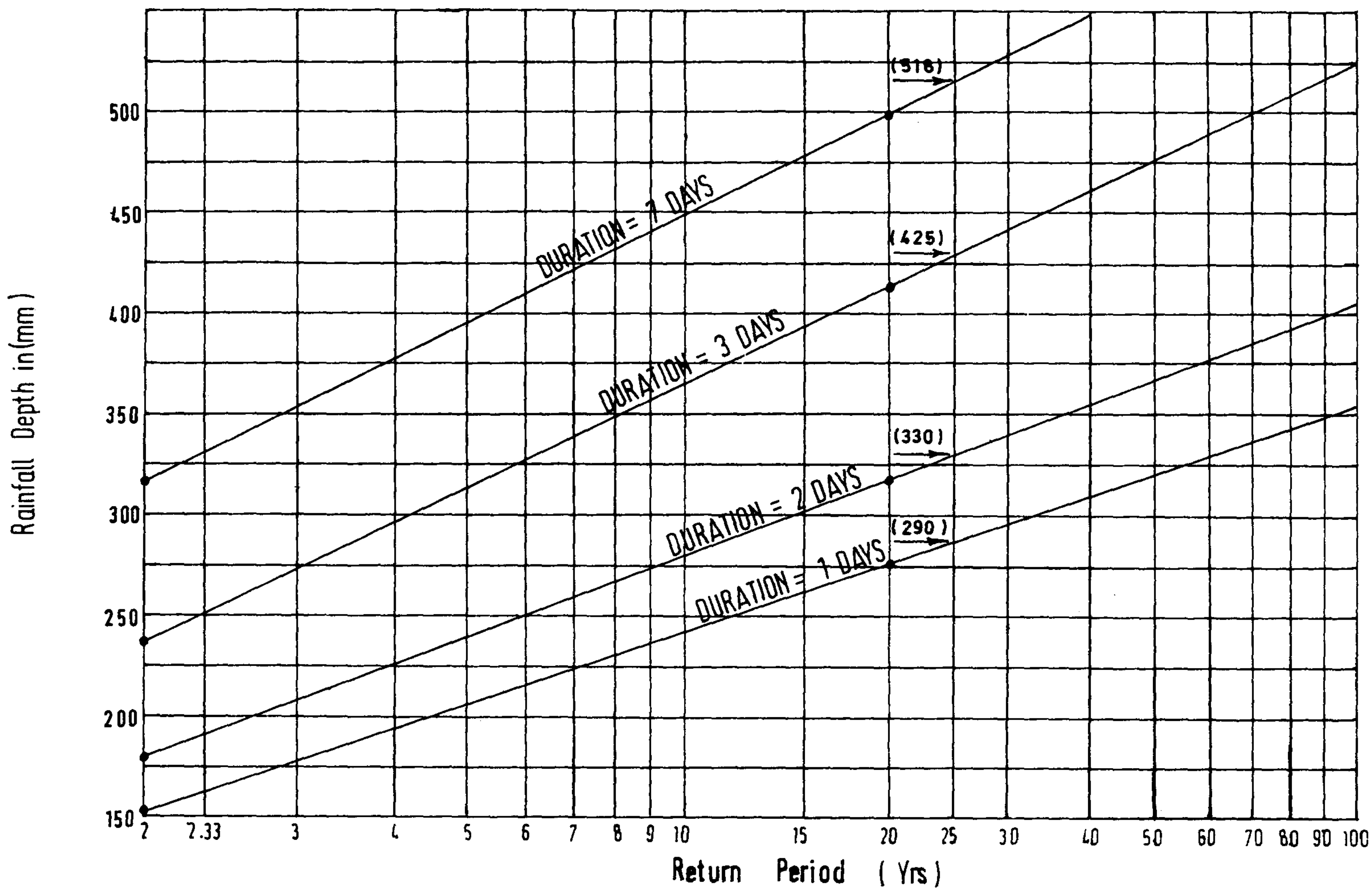


FIG. EX-1 (b) DETERMINATION OF X (25,4) FROM RAINFALL DEPTH—DURATION DIAGRAM.

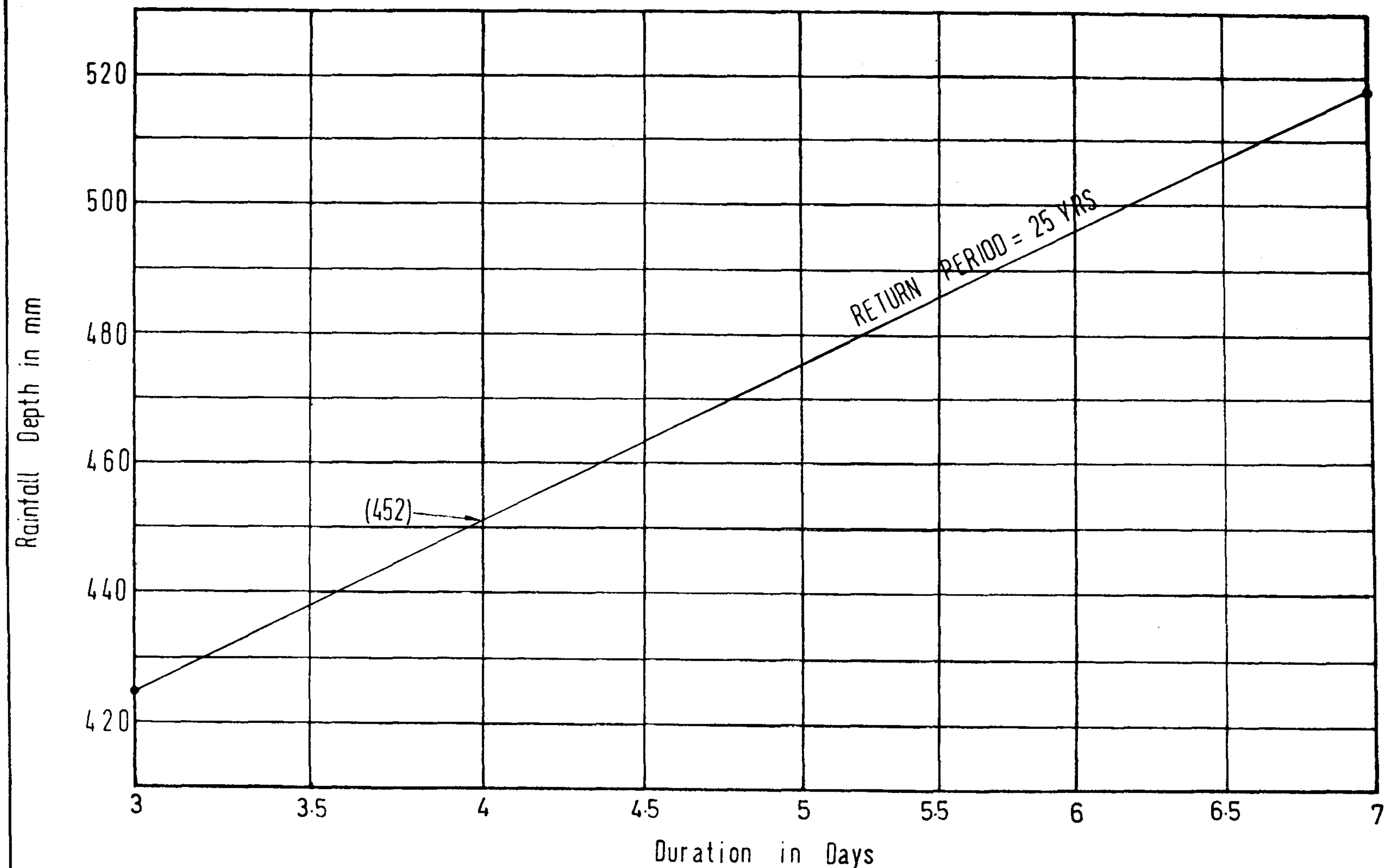
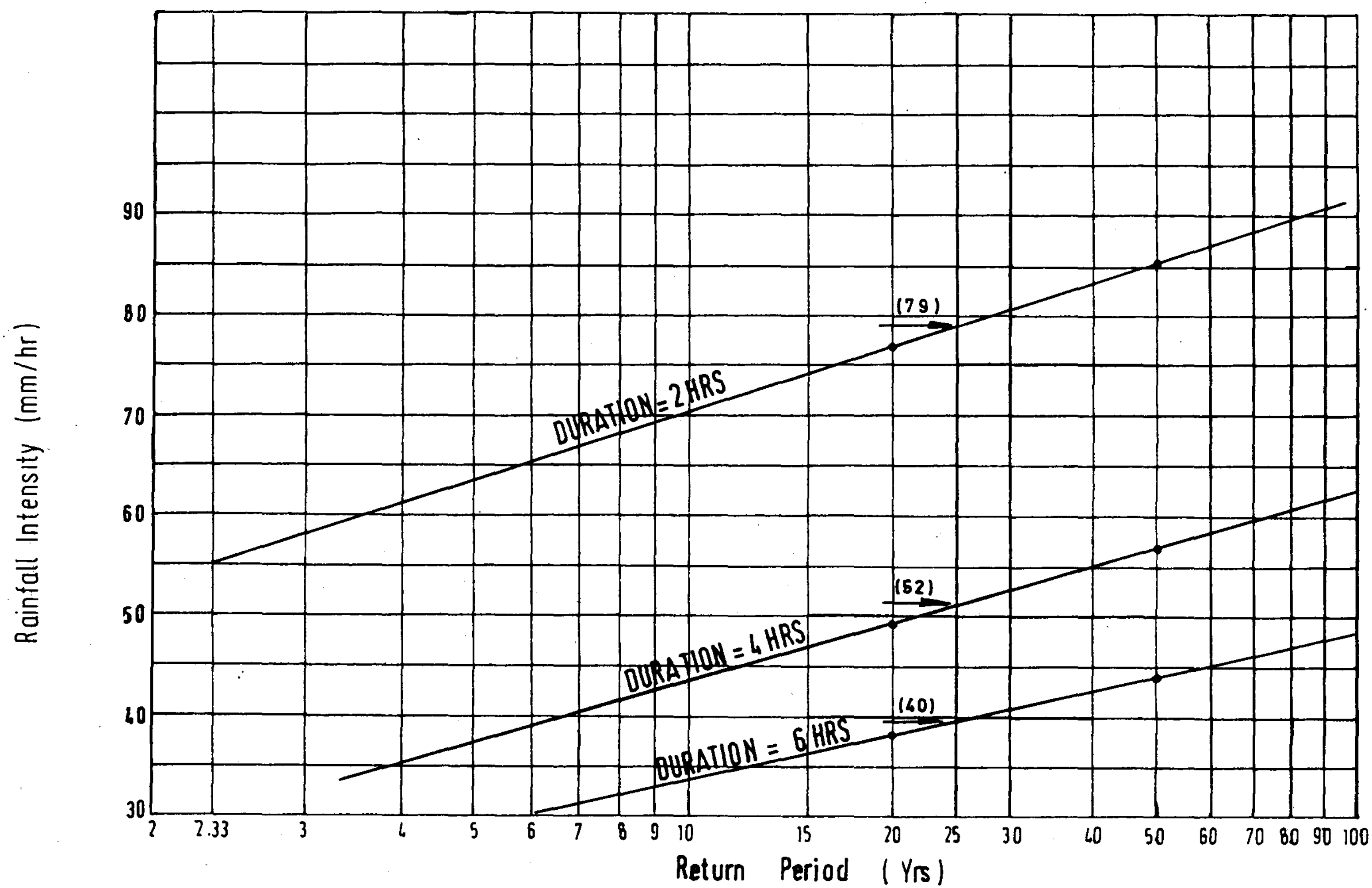


FIG. EX-2 EXAMPLE 2 RAINFALL INTENSITY-RETURN PERIOD PLOTTING DIAGRAM FOR CONSTANT STORM DURATION.



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APPENDIX A

SUMMARY OF DATA USED IN STUDY

(a) Manual Station (Sabah):

No.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge†*
1.	4276001	1960/61-78/79	19	12	M5
2.	4278001	1967/68-78/79	12	6	M5
3.	4279001	1960/61-78/79	19	18	M5
4.	4358001	1964/65-78/79	13	396	M5
5.	4373001	1960/61-68/69	9	12	M5
6.	4474001	1962/63-78/79	17	12	M5
7.	4480001	1962/63-78/79	16	30	M5
8.	4480002	1962/63-78/79	15	183	M5
9.	4485001	1960/61-78/79	19	6	M5
10.	4562001	1960/61-78/79	19	183	M5
11.	4576001	1964/65-71/72	8	90	M5
12.	4584001	1960/61-78/79	17	46	M5
13.	4681001	1960/61-78/79	19	122	M5
14.	4764002	1965/66-74/75	9	280	M5
15.	5055001	1961/62-78/79	18	2	M5
16.	5059001	1965/66-78/79	13	210	M5
17.	5059002	1959/60-78/79	19	183	M5
18.	5083001	1961/62-78/79	16	6	M5
19.	5083002	1959/60-78/79	19	6	M5
20.	5088001	1968/69-74/75	6	30	M5
21.	5159001	1959/60-78/79	19	195	M5
22.	5252001	1959/60-78/79	19	10	M5
23.	5261001	1967/68-78/79	10	259	M5
24.	5274001	1960/61-66/67	6	20	M5
25.	5357004	1960/61-76/77	17	9	M5
26.	5361001	1960/61-78/79	17	305	M5
27.	5364001	1959/60-78/79	19	366	M5

† M5 = 5 in. (127 mm.) Orifice Manual Raingauge.

SUMMARY OF DATA USED IN STUDY—(cont.)

ı) Manual Station (Sabah)—*(cont.)*

No.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge†*
28.	5384001	1959/60-70/71	10	183	M5
29.	5457001	1959/60-78/79	19	30	M5
30.	5457002	1959/60-78/79	19	9	M5
31.	5458003	1965/66-78/79	13	6	M5
32.	5461001	1965/66-78/79	11	370	M5
33.	5462002	1963/64-78/79	16	300	M5
34.	5462003	1961/62-78/79	12	457	M5
35.	5485001	1960/61-69/70	9	75	M5
36.	5487001	1965/66-78/79	13	30	M5
37.	5556001	1960/61-78/79	19	3	M5
38.	5659002	1960/61-78/79	19	15	M5
39.	5678001	1960/61-68/69	9	18	M5
40.	5759001	1960/61-78/79	19	3	M5
41.	5759002	1960/61-78/79	19	9	M5
42.	5864001	1965/66-78/79	14	700	M5
43.	5960001	1960/61-78/79	16	3	M5
44.	5965001	1960/61-78/79	19	1,123	M5
45.	5966002	1960/61-78/79	18	1,372	M5
46.	5967001	1960/61-78/79	19	549	M5
47.	5980001	1960/61-78/79	16	18	M5
48.	5980002	1969/70-78/79	10	18	M5
49.	6065001	1960/61-78/79	19	2,146	M5
50.	6162002	1960/61-78/79	18	18	M5
51.	6565001	1966/67-76/77	11	122	M5
52.	6567001	1960/61-78/79	19	9	M5
53.	6568001	1960/61-70/71	8	9	Close on 12/71 M5
54.	6868001	1960/61-68/69	9	20	M5

† M5 = 5 in. (127 mm.) Orifice Manual Raingauge.

SUMMARY OF DATA USED IN STUDY—(cont.)

(b) Manual Station (Sarawak):

Bil.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge*†
1.	0905039	1967/68-77/78	11	—	M5
2.	1003031	1965/66-77/78	13	—	M5
3.	1006028	1962/63-77/78	16	—	M5
4.	1007040	1966/67-77/78	12	—	M5
5.	1008032	1964/65-77/78	14	—	M5
6.	1102019	1962/63-77/78	11	—	M5
7.	1111008	1963/64-77/78	14	—	M5
8.	1113028	1969/70-77/78	9	—	M8
9.	1204024	1961/62-77/78	17	—	M5
10.	1205006	1963/64-77/78	15	—	M5
11.	1219024	1966/67-77/78	8	—	M8
12.	1220025	1972/73-77/78	6	—	M8
13.	1301074	1970/71-77/78	8	—	M5
14.	1306055	1966/67-77/78	12	—	M5
15.	1307018	1955/56-77/78	23	—	M5
16.	1311003	1963/64-77/78	15	—	M8
17.	1313006	1959/60-77/78	18	—	M8
18.	1402047	1959/60-77/78	19	—	M5
19.	1404049	1964/65-77/78	14	—	M5
20.	1415004	1950/51-77/78	28	—	M8
21.	1502026	1949/50-77/78	29	—	M8
22.	1503025	1958/59-77/78	20	—	M8
23.	1506034	1964/66-77/78	14	—	M5
24.	1509009	1962/63-77/78	13	—	M5
25.	1603058	1970/71-77/78	8	—	M5
26.	1612030	1970/71-77/78	8	—	M5
27.	1615023	1966/67-77/78	12	—	M5

† M5 = 5 in. (127 mm.) Orifice Manual Raingauge.
M8 = 8 in. (203 mm.) Orifice Manual Raingauge.

SUMMARY OF DATA USED IN STUDY—(cont.)

(b)* Manual Station (Sarawak)—*(cont.)

Bil.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge*†
28.	1704013	1959/60-77/78	19	—	M5
29.	1713005	1950/51-77/78	28	—	M8
30.	1722040	1971/72-76/77	5	—	M8
31.	1726041	1965/66-75/76	9	—	M5
32.	1811007	1963/64-77/78	15	—	M5
33.	1811010	1965/66-77/78	13	—	M8
34.	1816029	1963/64-74/75	10	—	M5
35.	1897016	1963/64-77/78	11	—	M5
36.	2019024	1963/64-77/78	15	—	M5
37.	2112027	1963/64-77/78	14	—	M8
38.	2116030	1964/65-77/78	14	—	M5
39.	2231043	1964/65-77/78	12	—	M5
40.	2318007	1953/54-77/78	25	—	M5
41.	2320059	1970/71-77/78	8	—	M5
42.	2325039	1965/66-77/78	12	—	M5
43.	2333044	1970/71-76/77	6	—	M5
44.	2338047	1964/65-77/78	8	—	M8
45.	2418013	1962/63-77/78	16	—	M5
46.	2514004	1962/63-77/78	16	—	M5
47.	2520052	1969/70-77/78	9	—	M5
48.	2524038	1965/66-77/78	9	—	M5
49.	2615009	1962/63-77/78	15	—	M5
50.	2625051	1965/66-77/78	8	—	M5
51.	2640035	1968/69-73/74	6	—	M5
52.	2718022	1963/64-77/78	15	—	M5
53.	2737003	1962/63-77/78	15	—	M5
54.	2828025	1963/64-77/78	15	—	M5

† M5 = 5 in. (127 mm.) Orifice Manual Raingauge.
M8 = 8 in. (203 mm.) Orifice Manual Raingauge.

SUMMARY OF DATA USED IN STUDY—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

Bil.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge*†
55.	2920005	1950/51-77/78	25	—	M5
56.	2925010	1960/61-76/77	17	—	M5
57.	2931038	1965/66-77/78	9	—	M5
58.	3048026	1962/63-77/78	16	—	M5
59.	3050015	1963/64-77/78	15	—	M5
60.	3132023	1963/64-77/78	12	—	M5
61.	3137021	1962/63-77/78	11	—	M5
62.	3152011	1963/64-77/78	15	—	M5
63.	3342032	1968/69-76/77	7	—	M5
64.	3347003	1962/63-77/78	14	—	M5
65.	3444018	1962/63-77/78	16	—	M5
66.	3451028	1962/63-73/74	10	—	M5
67.	3541033	1969/70-76/77	8	—	M5
68.	3744009	1962/63-78/79	10	—	M5
69.	3837016	1962/63-77/78	14	—	M5
70.	3842034	1969/70-77/78	6	—	M5
71.	3847035	1969/70-77/78	9	—	M5
72.	3945017	1963/64-77/78	11	—	M5
73.	3950020	1963/67-77/78	13	—	M5
74.	4038006	1952/53-76/77	25	—	M5
75.	4039019	1971/72-76/77	6	—	M5
76.	4139047	1969/70-76/77	8	—	M5
77.	4143004	1959/60-77/78	19	—	M5
78.	4239048	1969/70-77/78	9	—	M5
79.	4339005	1946/47-77/78	32	—	M5
80.	4440001	1952/53-76/77	25	—	M5
81	4449012	1963/64-77/78	15	—	M5

† M5 = 5 in. (127 mm.) Orifice Manual Raingauge.

SUMMARY OF DATA USED IN STUDY—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

Bil.	*Station Number*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L. (M)*	*Type of Gauge*†
82.	4548004	1950/51-77/78	28	—	M5
83.	4749010	1962/63-75/76	14	—	M5
84.	4752022	1971/72-77/78	7	—	M5
85.	4852002	1962/63-75/76	14	—	M5
86.	4955021	1972/73-77/78	6	—	M5

SUMMARY OF DATA USED IN STUDY—(cont.)

(c) Manual Stations where the length of Records Varies for Different Durations (Sabah and Sarawak):

No.	*Station Number*	*Duration (days)*	*Period of Record*	*No. Yrs. Used*	*Approx. Ht. Above M.S.L.*	*Remarks*
1.	1018002	1, 2, 3, 5	1950/51-77/78	24		M5
		7, 14, 30	1959/60-77/78	16		
2.	1105050	1, 2, 3, 5	1933/34-77/78	23		M5
		7, 14, 30	1965/66-77/78	13		
3.	1214001	1, 2, 3, 5	1935/36-77/78	38		M8
		7, 14, 30	1950/51-77/78	28		
4.	1401005	1, 2, 3, 5	1931/32-77/78	34		M5
		7, 14, 30	1954/55-77/78	23		
5.	1403001	1, 2, 3, 5	1950/51-77/78	27		M5
		7, 14, 30	1957/58-77/78	21		
6.	1698007	1, 2, 3, 5	1924/25-77/78	45		M5
		7, 14, 30	1955/56-77/78	22		
7.	2021036	1, 2, 3, 5	1948/49-77/78	25		M5
		7, 14, 30	1964/65-77/78	14		
8.	2025012	1, 2, 3, 5	1950/51-71/72	15		M5
		7, 14, 30	1963/64-71/72	9		
9.	2029001	1, 2, 3, 5	1948/49-77/78	24		M5
		7, 14, 30	1956/57-77/78	17		
10.	2115008	1, 2, 3, 5	1935/36-70/71	13		M5
		7, 14, 30	1963/64-70/71	8		
11.	2218017	1, 2, 3, 5	1931/32-77/78	31		M5
		7, 14, 30	1962/63-77/78	16		
12.	3130002	1, 2, 3, 5	1932/33-77/78	32		M5
		7, 14, 30	1935/36-77/78	18		
13.	4255006	1, 2, 3, 5	1950/51-77/78	23		M8
		7, 14, 30	1963/64-77/78	15		
14.	4650007	1, 2, 3, 5	1948/49-77/78	21		M5
		7, 14, 30	1966/67-77/78	11		
15.	4854003	1, 2, 3, 5	1948/49-75/76	28		M5
		7, 14, 30	1948/49-75/76	41		

Appendix A—*(cont.)*

SUMMARY OF DATA USED IN STUDY—*(cont.)*

(d) Recorder Stations (Sabah and Sarawak):

No.	*Station Name*	*Station Number*	*Length of Record*	*Type of Recorder*	*Approximate Height above MSL (M)*
	Sabah				
1.	Kota Kinabalu ..	5960002	24	CW (MMS)	3
2.	Sandakan	5880001	24	CW (MMS)	12
3.	Labuan	5252002	13	CW (MMS)	30
4.	Keningau	5361002	16	KW (DID)	290
5.	Ranau	6064001	21	HL (DID)	945
6.	Kudat	6868001	8	HL (DID)	20
7.	Kuamut	5274001	12	HL (DID)	50
8.	Tawau	4278002	11	KW (DID)	6
	Sarawak				
1.	Kuching	1403001	30	CW (MMS)	26
2.	Sibu	2318007	19	CW (MMS)	8
3.	Miri	4339005	28	CD (MMS)	17
4.	Bintulu	3130002	28	CD (MMS)	3
5.	Simanggang ..	1214001	18	HD (DID)	
6.	Kapit	2029001	10	KD (DID)	
7.	Belaga	2737003	16	KW (DID)	
8.	Limbang	4650023	7	KW (DID)	

N.B.—
CW—Casella Weekly
CD—Casella Daily
KW—Kent Weekly
KD—Kent Daily
HL—Hattori Longterm
HD—Hattori Daily

APPENDIX B

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.

(a) Manual Station (Sabah):

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
1.	4276001	19	2	96.6	121.5	135.5	144.6	170.6	242.6	345.9
			5	113.1	163.5	189.2	210.7	241.3	304.1	447.3
			10	124.1	191.3	224.7	254.5	288.0	344.9	514.5
			20	134.6	217.9	258.9	296.5	332.9	384.0	579.0
2.	4278001	12	2	107.7	130.6	144.0	149.8	172.4	225.6	325.1
			5	155.7	194.6	207.1	212.1	233.7	281.5	377.6
			10	187.4	237.0	248.8	253.4	274.2	318.4	412.3
			20	217.8	277.6	288.8	293.0	313.2	353.9	445.6
3.	4279001	19	2	109.3	124.4	140.0	150.1	170.3	237.2	348.1
			5	141.6	189.9	203.8	211.1	234.0	308.2	415.7
			10	162.9	233.1	245.9	251.4	276.1	355.2	460.5
			20	183.3	274.6	286.4	290.2	316.5	400.4	503.5
4.	4358001	13	2	67.0	95.4	109.9	130.9	155.1	214.9	329.6
			5	92.7	127.6	150.8	191.5	226.0	316.5	514.4
			10	109.7	149.0	178.0	231.6	272.9	383.7	636.7
			20	126.0	169.5	204.0	270.0	317.9	448.3	754.1
5.	4373001	9	2	95.1	116.5	125.2	130.7	152.1	215.4	341.8
			5	130.2	157.0	168.3	168.6	189.0	266.5	415.4
			10	153.4	183.8	196.9	193.6	213.4	300.3	464.1
			20	175.8	209.5	224.3	217.7	236.8	332.8	510.9
6.	4474001	17	2	107.3	121.6	137.0	148.9	169.4	237.1	355.0
			5	148.2	162.8	184.7	191.0	207.0	285.0	429.1
			10	175.3	189.9	216.3	218.9	231.8	316.7	478.2
			20	201.3	215.9	245.6	245.6	255.7	347.1	525.3

APPENDIX B—*(cont.)*

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
7.	4480001	16	2	93.20	111.2	129.2	151.1	174.0	256.4	417.4
			5	111.40	148.5	168.6	188.8	218.7	307.9	499.5
			10	128.20	173.1	194.7	213.8	248.3	342.1	553.9
			20	141.6	196.8	219.8	237.8	276.8	374.9	606.1
8.	4480002	15	2	102.4	120.6	137.9	158.8	178.2	256.8	402.4
			5	140.2	174.0	198.5	236.8	270.8	343.4	490.2
			10	165.3	209.2	238.7	288.5	332.0	400.7	548.3
			20	189.3	243.1	277.3	338.1	390.9	455.7	604.0
9.	4485001	19	2	115.9	142.3	164.3	183.8	204.8	271.6	397.9
			5	171.3	204.2	224.2	243.6	270.6	365.5	531.9
			10	207.9	245.2	264.1	283.2	314.2	427.7	620.6
			20	243.0	284.5	302.4	321.2	356.1	487.3	705.7
10.	4562001	19	2	112.5	136.7	158.7	186.8	220.8	317.7	521.0
			5	146.1	170.7	190.1	225.5	268.3	374.5	591.6
			10	168.5	193.3	210.7	251.1	299.7	412.1	683.2
			20	189.8	214.9	230.6	275.7	329.8	448.3	741.3
11.	4576001	8	2	84.9	116.2	121.5	130.6	155.3	200.8	318.1
			5	108.9	159.4	169.2	184.2	210.5	262.2	394.8
			10	124.3	187.9	200.8	219.7	247.1	302.9	445.6
			20	139.3	215.3	231.2	253.7	282.2	341.9	494.4
12.	4584001	17	2	125.8	151.6	174.3	195.9	231.4	311.0	464.0
			5	188.3	239.4	289.2	308.3	383.1	512.8	775.0
			10	229.7	297.5	365.2	382.8	483.5	646.5	982.0
			20	269.4	353.3	438.2	454.3	580.0	774.7	1,180.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
13.	4681001	19	2	105.4	122.1	142.3	163.2	182.6	245.1	376.3
			5	132.9	156.4	184.4	213.5	243.9	316.1	444.5
			10	151.0	179.1	212.2	246.8	284.5	363.1	489.6
			20	168.5	200.8	238.9	278.7	323.4	408.2	533.0
14.	4764002	9	2	128.2	164.9	189.5	216.2	234.2	308.9	506.9
			5	200.1	247.5	285.3	297.8	304.7	389.4	617.9
			10	247.7	302.3	348.7	351.8	351.4	442.7	691.4
			20	293.3	354.8	409.7	403.6	396.2	493.8	762.0
15.	5055001	18	2	150.0	175.6	195.9	229.9	261.0	371.1	576.5
			5	219.1	256.4	277.5	335.8	366.0	506.2	755.4
			10	264.9	309.9	231.6	406.0	435.6	595.6	873.9
			20	308.8	361.2	383.4	473.3	502.3	681.5	987.7
16.	5059001	13	2	76.7	92.8	113.2	125.5	139.9	202.2	297.0
			5	101.3	120.4	143.5	153.2	159.6	230.9	350.0
			10	117.6	138.7	163.7	171.6	172.7	250.0	385.0
			20	133.3	156.2	183.1	189.2	185.2	168.2	418.7
17.	5059002	19	2	86.6	103.2	115.2	132.3	156.6	208.3	316.5
			5	123.7	142.4	150.7	173.5	200.5	274.9	424.1
			10	148.2	168.5	174.2	200.8	229.5	319.0	495.3
			20	171.8	193.3	196.7	226.9	257.4	361.3	563.7
18.	5083001	16	2	132.3	158.3	172.1	193.3	215.8	276.2	383.3
			5	222.8	289.5	314.1	339.4	368.3	433.9	561.8
			10	282.5	376.5	408.1	436.2	469.2	538.3	680.0
			20	339.9	459.7	498.4	529.1	566.0	638.5	793.4

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a)* Manual Station (Sabah)—*(cont.)

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
19.	5083002	19	2	140.4	144.7	171.4	189.9	215.3	273.9	428.9
			5	320.2	249.2	301.4	327.2	348.5	429.2	512.3
			10	439.4	318.3	387.3	418.1	436.8	532.0	737.0
			20	553.6	384.7	469.9	505.4	521.4	630.8	856.8
20.	5088001	6	2	105.9	118.8	129.4	157.7	176.8	207.0	327.8
			5	208.3	222.3	232.6	302.2	319.8	345.8	508.1
			10	276.0	290.7	300.7	397.8	414.4	437.7	627.6
			20	341.0	356.5	366.3	489.7	505.3	526.0	742.2
21.	5159001	19	2	96.8	112.6	131.1	142.6	170	224.7	341.5
			5	168.1	208.7	219.4	252.9	270.9	360.5	533.1
			10	215.3	272.3	277.8	325.9	337.6	450.4	659.9
			20	260.7	333.3	334.0	396.0	401.7	536.7	781.7
22.	5252001	19	2	178.4	212.9	242.6	270.1	308.1	430.4	659.3
			5	255.6	289.9	328.4	353.8	396.5	536.4	793.3
			10	306.7	340.8	385.2	409.2	454.9	606.6	882.0
			20	355.7	389.8	439.8	462.3	511.1	674.0	967.1
23.	5261001	10	2	73.8	100.2	114.4	134.4	153.2	203.9	308.6
			5	84.1	132.0	170	217.1	236.0	282.4	406.3
			10	91.0	153.0	206.9	271.8	290.7	334.3	471.0
			20	97.6	173.3	242.3	324.8	343.3	384.1	533.1
24.	5274001	6	2	117.6	146.0	190.7	219.3	249.0	334.4	530.8
			5	163.4	227.3	266.4	315.5	353.1	459.4	738.6
			10	193.7	281.1	316.4	379.2	422.0	542.1	876.1
			20	222.8	332.7	364.5	440.3	488.2	621.5	1,008.1

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
25.	5357004	17	2	163.2	195.7	227.3	264.9	317.4	423.6	655.0
			5	219.1	247.3	290.5	337.4	403.3	513.3	797.7
			10	256.2	281.6	332.4	385.4	460.2	572.7	892.1
			20	291.6	314.4	372.6	431.5	514.8	629.7	982.7
26.	5361001	17	2	93.0	109.0	119.7	132.3	150.5	201.4	307.1
			5	125.5	136.7	153.1	167.7	187.6	245.3	379.9
			10	146.9	155.2	175.2	191.2	212.2	274.4	428.1
			20	167.6	172.9	196.4	213.7	235.7	302.4	474.4
27.	5364001	19	2	104.5	141.3	159.5	186.7	209.5	277.0	398.2
			5	131.7	175.9	196.5	242.1	272.1	341.4	508.2
			10	149.7	199.0	221.7	278.7	313.6	384.0	581.0
			20	166.9	221.1	245.5	313.9	353.4	425.0	650.9
28.	5384001	10	2	156.5	204.8	251.7	287.1	320.9	424.8	643.0
			5	257.6	333.6	427.5	471.2	504.0	647.6	989.0
			10	324.5	418.8	543.9	593.1	625.2	795.0	1,217.0
			20	388.9	500.7	549.5	710.1	741.6	936.6	1,437.0
29.	5457001	19	2	140.6	189.4	218.8	259.7	319.0	431.3	669.6
			5	209.3	259.1	293.5	342.9	413.5	533.5	833.7
			10	254.7	305.2	343.0	397.9	476.0	601.0	942.4
			20	298.3	349.5	390.5	450.8	536.0	665.9	1,046.7
30.	5457002	19	2	160.4	201.3	243.8	285.4	326.4	444.9	683.0
			5	238.8	278.2	351.4	409.4	453.9	583.4	858.0
			10	290.9	329.0	422.6	491.5	538.4	675.1	975.0
			20	340.7	377.8	491.0	570.3	619.4	763.1	1,086.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	Station Number	Length of Record (n)	Return Period (T)	Duration (t) Days						
				1	2	3	5	7	14	30
31.	5458003	13	2	142.3	194.8	221.7	257.3	291.8	420.3	648.8
			5	192.3	278.2	308.9	349.2	386.4	547.2	821.7
			10	225.5	333.5	366.6	410.1	449.0	631.2	936.2
			20	257.3	386.4	422.1	468.5	509.2	711.9	1,046.1
32.	5461001	11	2	79.2	88.1	97.8	107.4	121.9	179.1	277.9
			5	98.7	108.9	120.3	135.3	159.1	210.9	327.6
			10	111.6	122.7	135.0	153.8	183.7	231.9	360.6
			20	123.9	135.9	149.2	171.6	207.3	252.1	392.2
33.	5462002	16	2	73.6	90.2	105.0	126.3	140.7	194.9	278.3
			5	96.5	120.2	133.2	162.6	179.4	254.8	366.1
			10	111.7	140.0	152.0	186.6	205.0	294.4	424.2
			20	126.3	159.1	169.9	209.7	229.6	332.4	480.0
34.	5462003	12	2	85.1	112.8	142.0	166.7	185.8	253.5	375.8
			5	126.6	180.5	226.6	263.6	294.4	375.1	570.2
			10	154.1	225.3	282.7	327.8	366.2	455.6	698.8
			20	180.5	268.3	336.4	389.4	345.2	532.6	322.3
35.	5485001	9	2	117.9	151.10	189.0	241.1	269.4	353.1	569.0
			5	183.2	242.7	304.4	393.5	421.2	520.7	866.0
			10	226.4	303.4	380.9	494.3	521.8	631.7	1,063.0
			20	267.8	361.6	454.3	591.1	618.3	738.2	1,251.0
36.	5487001	13	2	160.3	224.2	256.1	295.9	336.6	434.0	661.0
			5	259.1	400.6	445.1	515.4	592.3	728.0	1,024.0
			10	324.5	517.4	570.2	660.8	761.5	922.0	1,265.0
			20	387.4	629.5	690.3	800.3	924.0	1,108.0	1,495.0

APPENDIX B—*(cont.)*

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
37.	5556001	19	2	164.5	185.7	210.8	231.8	260.3	334.6	488.2
			5	238.1	265.6	303.3	323.9	341.1	428.7	635.2
			10	286.8	318.4	364.5	384.8	394.6	491.1	732.4
			20	333.6	369.1	423.3	443.3	445.9	550.9	825.8
38.	5659002	19	2	162.1	207.4	236.7	269.7	317.7	413.1	655.0
			5	199.6	271.8	302.5	341.8	403.3	517.9	811.0
			10	224.6	314.5	346.1	389.6	459.9	587.3	914.0
			20	248.4	355.4	388.0	435.5	514.3	653.8	1,013.0
39.	5678001	9	2	161.0	202.3	236.5	265.0	293.9	432.9	611.2
			5	234.5	297.9	359.9	419.0	464.5	630.7	875.7
			10	283.3	361.3	441.6	521.0	577.4	761.5	1,050.8
			20	330.0	422.1	519.9	618.8	685.8	887.2	1,218.9
40.	5759001	19	2	166.9	193.3	208.7	233.9	270.3	361.7	522.3
			5	239.7	253.0	266.5	316.0	361.2	468.6	649.3
			10	288.0	292.5	304.7	370.3	421.4	539.3	733.4
			20	334.4	330.4	341.4	422.5	479.2	607.2	814.1
41.	5759002	19	2	117.7	217.4	247.0	276.2	320.0	420.3	634.1
			5	283.1	328.4	385.9	403.9	446.1	575.6	819.3
			10	352.7	407.0	478.1	488.4	529.6	678.4	941.9
			20	419.6	472.5	566.4	569.6	609.8	777.1	1,059.7
42.	5864001	14	2	77.7	105.7	125.2	146.3	167.4	247.5	367.9
			5	116.2	156.8	190.5	208.9	236.3	346.8	519.5
			10	141.6	190.6	233.7	250.4	282.0	412.5	619.9
			20	166.0	223.0	257.2	290.2	325.8	475.7	716.2

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

***(a)* Manual** Station (Sabah)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
43.	5960001	16	2	162.8	182.3	203.0	225.9	256.4	342.8	515.2
			5	213.5	240.2	256.8	286.4	314.9	417.7	636.8
			10	247.2	278.4	292.4	326.5	353.6	467.4	717.3
			20	279.5	315.3	326.6	365.0	390.8	515.0	794.6
44.	5965001	19	2	84.2	110.4	130.2	159.0	178.4	247.6	373.2
			5	137.1	162.2	179.3	226.1	247.0	331.6	464.8
			10	172.1	196.6	211.9	270.6	292.5	387.2	525.5
			20	205.8	229.6	243.2	313.2	336.1	440.6	583.7
45.	5966002	18	2	90.1	116.2	142.5	169.8	193.7	263.3	388.9
			5	139.4	181.8	214.9	243.8	272.6	357.1	496.8
			10	172.0	225.2	262.1	292.7	324.9	419.1	568.2
			20	203.4	266.9	308.8	339.7	375.0	478.7	636.8
46.	5967001	19	2	93.5	128.7	150.4	180.6	205.7	288.5	495.0
			5	165.1	229.5	252.5	286.3	314.0	432.6	1,085.0
			10	212.5	296.1	320.0	356.4	385.6	528.0	1,475.0
			20	258.0	360.1	384.9	423.6	454.4	619.6	1,850.0
47.	5980001	16	2	194.6	249.8	300.6	335.9	382.8	504.3	713.0
			5	293.5	355.0	461.1	501.0	543.7	712.1	988.0
			10	359.1	424.7	567.3	610.2	650.3	849.7	1,169.0
			20	422.0	491.4	669.4	715.1	752.5	981.7	1,344.0
48.	5980002	10	2	256.5	281.6	386.5	424.6	477.4	610.6	900.0
			5	365.4	403.3	548.5	605.6	660.9	798.6	1,150.0
			10	437.5	492.8	655.8	725.4	782.3	923.0	1,500.0
			20	506.7	573.6	758.8	840.4	898.8	1,042.4	1,700.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(a) Manual Station (Sabah)—*(cont.)*

No.	Station Number	Length of Record (n)	Return Period (T)	Duration (t) Days						
				1	2	3	5	7	14	30
49.	6065001	19	2	146.5	195.2	223.1	276.2	336.1	484.8	772.0
			5	193.6	254.3	286.0	370.9	471.5	655.0	955.0
			10	224.7	293.4	327.6	433.7	561.1	767.6	1,077.0
			20	254.7	331.0	367.5	493.9	647.2	875.7	1,194.0
50.	6162002	18	2	119.7	145.5	165.4	187.4	208.2	282.5	434.1
			5	165.3	193.4	225.8	281.9	318.7	395.7	565.6
			10	195.5	225.1	265.8	344.5	319.9	470.7	652.6
			20	224.5	255.6	304.2	404.5	462.1	542.7	736.2
51.	6565001	11	2	154.5	199.3	255.5	301.5	344.5	443.4	615.0
			5	221.3	298.1	380.1	479.3	566.0	685.5	937.0
			10	265.5	363.4	462.7	597.1	712.6	845.8	1,150.0
			20	307.9	426.4	542.0	710.2	853.4	999.7	1,354.0
52.	6567001	19	2	137.9	196.0	235.9	291.6	347.0	478.0	684.0
			5	213.7	325.3	400.5	515.5	623.0	810.0	1,133.0
			10	264.1	410.7	509.3	663.6	806.0	1,029.0	1,431.0
			20	312.4	492.8	614.1	805.9	981.0	1,240.0	1,716.0
53.	6568001	8	2	84.1	128.0	182.7	236.9	286.0	406.9	644.0
			5	120.8	163.0	249.2	323.7	400.4	576.7	968.0
			10	145.2	186.1	293.3	381.1	476.2	689.0	1,182.0
			20	168.6	208.3	335.6	436.3	548.9	796.9	1,387.0
54.	6868001	9	2	198.0	213.0	228.6	261.3	293.3	427.6	620.0
			5	381.3	389.7	413.8	446.9	504.4	738.0	1,021.0
			10	502.6	506.5	536.4	569.8	644.1	943.5	1,287.0
			20	619.0	618.8	548.1	687.8	778.3	1,140.7	1,542.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak):

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
1.	0905039	11	2	124.8	169.9	199.6	227.9	262.3	345.5	528.4
			5	160.1	219.0	255.8	292.5	333.8	422.4	657.8
			10	183.3	251.5	293.0	335.2	381.1	473.3	743.5
			20	205.5	282.7	328.6	376.3	426.5	522.2	825.7
2.	1003031	13	2	114.1	152.8	184.2	220.2	251.6	326.2	505.1
			5	163.2	224.9	278.3	315.8	353.8	428.1	850.6
			10	195.7	272.5	340.6	379.1	421.5	495.5	747.0
			20	226.9	318.2	400.4	439.8	486.5	560.3	839.4
3.	1006028	16	2	144.7	183.7	212.1	243.7	282.0	365.1	555.3
			5	195.7	262.3	313.2	349.1	401.0	482.7	736.0
			10	239.7	314.4	380.1	418.9	479.7	560.6	855.6
			20	276.1	364.4	444.4	485.9	555.3	635.3	970.5
4.	1007040	12	2	117.0	152.7	176.4	238.3	238.3	343.0	526.0
			5	153.9	223.7	256.3	329.6	329.6	466.0	719.0
			10	178.4	270.8	309.2	390.0	390.0	547.0	846.0
			20	201.9	315.8	360.1	448.0	448.0	625.0	968.0
5.	1008032	14	2	130.2	165.7	201.7	247.9	294.1	426.4	664.0
			5	157.9	210.9	275.7	345.3	393.5	569.8	846.0
			10	176.1	240.8	324.7	409.3	459.3	664.7	966.0
			20	193.7	269.6	371.7	471.7	522.4	755.8	1,081.0
6.	1018002	24	2	120.5	143.1	167.6	200.0	239.0	339.0	523.0
			5	163.5	191.5	218.9	259.8	320.0	438.0	710.0
			10	192.0	223.6	257.0	299.4	374.0	503.0	834.0
			20	219.3	254.3	285.4	337.4	426.0	566.0	954.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
7.	1102019	11	2	119.7	165.3	196.5	231.3	270.3	369.0	577.0
			5	165.8	244.4	300.1	343.0	404.9	518.0	754.0
			10	196.2	296.8	368.6	416.9	494.1	617.0	871.0
			20	255.4	347.0	434.4	487.9	579.6	712.0	983.0
8.	1105050	23	2	122.6	153.0	183.1	213.2	273.9	380.7	563.0
			5	164.7	201.9	251.4	285.8	372.8	503.3	755.0
			10	192.7	234.4	296.8	333.9	438.2	584.5	882.0
			20	219.5	265.4	340.3	380.0	501.1	662.4	1,004.0
9.	1111008	14	2	125.5	170.6	196.0	234.8	269.2	380.3	632.0
			5	153.4	204.9	236.3	303.2	346.4	450.6	780.0
			10	171.9	227.6	262.9	348.4	397.2	497.2	878.0
			20	189.7	249.4	288.4	391.9	446.5	541.9	972.0
10.	1113028	9	2	146.5	172.4	195.4	224.8	262.4	382.5	626.0
			5	186.6	225.1	285.6	314.7	381.4	494.4	830.0
			10	213.2	260.1	345.2	374.3	460.1	568.4	964.0
			20	238.7	293.5	402.5	431.4	535.7	639.5	1,094.0
11.	1204024	17	2	166.8	232.2	262.9	308.0	355.0	464.0	712.0
			5	232.4	343.4	412.3	461.0	525.0	628.0	981.0
			10	276.0	418.0	510.9	563.0	638.0	736.0	1,159.0
			20	317.7	488.2	605.3	660.0	746.0	840.0	1,330.0
12.	1205006	15	2	157.4	208.8	238.5	276.0	333.0	450.0	702.0
			5	217.3	298.9	356.2	400.0	474.0	608.0	952.0
			10	256.8	358.7	434.6	482.0	568.0	712.0	1,118.0
			20	294.9	415.9	509.9	561.0	658.0	813.0	1,277.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
13.	1214001	38	2	134.7	156.4	176.8	208.9	241.0	361.0	654.0
			5	165.1	190.8	218.3	255.3	303.0	438.0	661.0
			10	185.3	213.6	245.7	286.1	344.0	489.0	725.0
			20	204.5	235.4	272.0	315.7	383.0	538.0	786.0
14.	1219024	8	2	127.9	166.5	183.1	224.2	261.4	412.0	671.0
			5	201.3	266.3	300.1	376.7	455.6	759.0	1,205.0
			10	250.0	332.4	377.7	477.6	584.1	989.0	1,559.0
			20	296.6	395.9	452.1	574.4	707.5	1,210.0	1,898.0
15.	1220025	6	2	107.0	134.7	154.0	206.3	247.9	387.0	583.0
			5	127.6	197.9	238.4	325.6	376.5	576.0	818.0
			10	141.2	239.7	294.3	404.5	461.7	701.0	973.0
			20	154.2	279.7	347.8	480.4	543.4	821.0	1,123.0
16.	1301074	8	2	204.9	264.5	364.7	422.0	489.0	621.0	942.0
			5	277.0	408.6	553.5	660.0	780.0	941.0	1,451.0
			10	324.8	504.0	678.4	818.0	972.0	1,152.0	1,789.0
			20	370.6	595.6	798.4	969.0	1,157.0	1,354.0	2,113.0
17.	1306055	12	2	183.4	251.4	295.4	348.0	395.0	512.0	769.0
			5	263.7	388.5	489.1	575.0	632.0	739.0	1,090.0
			10	316.8	479.2	617.2	725.0	789.0	890.0	1,303.0
			20	367.8	566.2	740.4	869.0	940.0	1,035.0	1,508.0
18.	1307018	23	2	200.6	251.0	282.0	315.0	357.0	475.0	779.0
			5	291.0	356.1	415.5	469.0	525.0	655.0	1,115.0
			10	350.8	425.7	503.5	571.0	637.0	775.0	1,336.0
			20	408.0	492.6	588.3	669.0	744.0	889.0	1,549.0

APPENDIX B—*(cont.)*

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
19.	1311003	15	2	143.2	175.2	205.7	243.0	285.5	391.0	599.0
			5	213.6	271.6	294.3	359.5	428.0	543.0	792.0
			10	260.2	335.6	352.9	436.7	522.4	644.0	921.0
			20	305.1	396.8	409.2	510.7	613.0	741.0	1,044.0
20.	1313006	18	2	134.9	160.9	178.4	209.9	250.3	358.0	575.0
			5	171.5	202.8	222.9	274.7	837.2	457.0	676.0
			10	195.6	230.6	252.4	317.7	394.7	523.0	743.0
			20	218.9	257.3	280.7	358.9	449.9	586.0	807.0
21.	1401005	34	2	162.5	209.6	256.2	306.8	415.0	551.0	845.0
			5	263.7	325.1	404.2	459.8	595.0	757.0	1,236.0
			10	330.7	401.4	502.1	561.1	714.0	893.0	1,495.0
			20	395.0	474.9	596.1	658.3	828.0	1,023.0	1,743.0
22.	1402047	19	2	208.6	257.0	252.3	367.4	430.9	559.0	882.0
			5	292.1	353.8	347.3	502.0	593.7	759.0	1,222.0
			10	347.2	417.9	410.1	591.1	701.5	891.0	1,447.0
			20	400.3	479.4	472.5	676.6	805.0	1,017.0	1,662.0
23.	1403001	27	2	199.4	251.2	296.3	345.2	432.0	567.0	886.0
			5	302.4	388.6	448.9	503.1	606.0	770.0	1,246.0
			10	370.7	479.5	550.0	607.7	721.0	904.0	1,484.0
			20	436.3	566.8	647.0	708.0	832.0	1,033.0	1,713.0
24.	1404049	14	2	234.0	297.0	351.9	411.0	461.0	630.0	941.0
			5	340.3	426.6	516.2	590.0	637.0	817.0	1,291.0
			10	410.6	513.0	626.5	709.0	754.0	941.0	1,522.0
			20	478.1	596.2	731.4	822.0	866.0	1,060.0	1,745.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
25.	1415004	28	2	129.5	183.9	183.9	221.0	261.0	396.0	626.0
			5	168.5	246.3	246.3	287.0	346.0	512.0	804.0
			10	194.4	287.7	287.7	331.0	402.0	588.0	922.0
			20	219.1	327.3	327.3	373.0	456.0	661.00	1,036.0
26.	1502026	29	2	195.3	315.9	315.9	385.0	440.0	593.0	931.0
			5	273.3	469.6	469.6	564.0	643.0	840.0	1,348.0
			10	324.9	571.3	571.3	683.0	776.0	1,004.0	1,625.0
			20	374.5	668.9	668.9	797.0	905.0	1,162.0	1,890.0
27.	1503025	20	2	221.4	325.5	325.5	387.8	463.3	601.0	949.0
			5	313.0	469.1	469.1	556.4	645.1	807.0	1,257.0
			10	373.7	564.1	564.1	668.0	765.4	942.0	1,462.0
			20	431.9	655.3	655.3	775.1	880.9	1,073.0	1,658.0
28.	1505034	14	2	249.0	372.1	372.1	459.0	528.0	696.0	972.0
			5	351.0	528.9	528.9	644.0	760.0	931.0	1,207.0
			10	418.0	631.8	631.8	766.0	913.0	1,086.0	1,363.0
			20	482.0	731.4	731.4	883.0	1,060.0	1,234.0	1,513.0
29.	1509009	13	2	192.8	276.3	276.3	321.6	384.0	568.0	842.0
			5	236.8	359.6	359.6	431.5	517.0	769.0	1,136.0
			10	266.0	414.7	414.7	504.3	606.0	902.0	1,331.0
			20	293.9	467.6	467.6	574.2	690.0	1,030.0	1,518.0
30.	1603058	8	2	202.0	302.1	302.1	372.0	440.0	631.0	1,006.0
			5	233.0	388.0	388.0	486.0	588.0	821.0	1,288.0
			10	253.0	445.2	445.2	561.0	686.0	947.0	1,475.0
			20	272.0	499.3	499.3	634.0	780.0	1,068.0	1,655.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	Station Number	Length of Record (n)	Return Period (T)	Duration (t) Days						
				1	2	3	5	7	14	30
31.	1612030	8	2	133.7	173.8	197.3	234.0	267.0	391.0	629.0
			5	180.2	225.2	277.1	345.0	425.0	584.0	890.0
			10	210.9	259.2	330.0	418.0	529.0	712.0	1,062.0
			20	240.4	291.9	380.0	489.0	629.0	834.0	1,227.0
32.	1615023	12	2	137.3	161.2	179.1	213.0	253.0	377.0	589.0
			5	186.8	209.9	227.9	278.0	328.0	473.0	687.0
			10	219.7	242.4	259.7	321.0	378.0	536.0	753.0
			20	251.3	273.3	291.5	362.0	426.0	597.0	815.0
33.	1698007	45	2	180.7	244.7	284.8	226.6	531.0	674.0	1,039.0
			5	279.6	369.7	423.4	342.3	715.0	878.0	1,361.0
			10	344.9	452.3	515.1	418.8	837.0	1,013.0	1,574.0
			20	407.4	531.7	603.1	492.3	954.0	1,142.0	1,779.0
34.	1704013	19	2	210.4	267.8	310.6	445.0	445.0	603.0	998.0
			5	277.1	366.1	431.4	596.0	596.0	779.0	1,246.0
			10	321.4	431.2	512.0	697.0	697.0	895.0	1,409.0
			20	363.8	493.7	588.3	793.0	793.0	1,007.0	1,566.0
35.	1713005	28	2	140.0	166.9	196.7	231.0	268.0	363.0	556.0
			5	195.1	223.3	259.1	293.0	336.0	446.0	663.0
			10	231.5	260.7	300.3	334.0	381.0	500.0	728.0
			20	266.5	296.6	339.8	374.0	424.0	553.0	790.0
36.	1722040	5	2	107.4	137.1	154.3	174.9	218.4	303.2	484.0
			5	146.5	188.6	212.3	230.1	315.3	471.3	721.2
			10	174.9	222.7	250.8	266.5	379.5	582.5	878.3
			20	202.0	255.4	287.7	301.6	441.1	689.3	1,029.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	Station Number	Length of Record (n)	Return Period (T)	Duration (t) Days						
				1	2	3	5	7	14	30
37.	1726041	9	2	131.0	166.9	190.6	235.7	283.8	416.8	630.0
			5	199.3	249.5	273.8	339.2	391.1	511.4	818.0
			10	244.5	303.4	328.8	407.7	462.1	574.0	942.0
			20	287.9	355.5	381.7	473.5	530.3	634.1	1,062.0
38.	1811007	15	2	167.7	229.6	264.2	314.7	356.2	482.4	774.0
			5	227.9	298.7	345.7	422.5	478.3	637.6	1,060.0
			10	267.7	344.5	399.6	493.8	559.1	740.3	1,250.0
			20	306.0	388.5	451.5	562.2	636.7	838.9	1,431.0
39.	1811010	13	2	168.4	212.1	247.0	309.0	356.0	476.0	716.0
			5	236.3	293.9	335.0	403.0	467.0	626.0	966.0
			10	281.4	348.0	393.3	465.0	541.0	726.0	1,132.0
			20	324.4	400.0	448.4	525.0	611.0	821.0	1,291.0
40.	1816029	10	2	149.2	172.8	190.7	218.5	250.0	363.0	615.0
			5	202.0	216.3	227.2	258.9	310.0	446.0	754.0
			10	236.9	245.1	251.3	285.7	350.0	501.0	846.0
			20	270.4	272.7	274.5	311.3	388.0	553.0	934.0
41.	1897016	11	2	194.7	266.1	318.1	395.8	461.5	640.9	1,040.0
			5	264.8	381.0	486.1	567.5	664.3	825.9	1,402.0
			10	311.1	456.9	597.4	681.2	798.6	948.3	1,642.0
			20	355.7	529.8	704.2	790.3	927.4	1,065.9	1,872.0
42.	2019024	15	2	138.1	174.1	198.5	239.5	280.7	407.0	623.0
			5	184.2	223.3	247.4	313.0	355.9	504.0	749.0
			10	214.8	255.9	279.8	361.6	405.7	569.0	832.0
			20	244.2	287.2	310.9	408.3	453.5	631.0	913.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
43.	2021036	25	2	129.7	152.6	167.2	195.9	224.0	312.0	499.0
			5	165.6	180.0	194.9	236.7	272.0	371.0	591.0
			10	189.6	198.3	213.3	263.7	303.0	411.0	653.0
			20	212.3	215.8	231.0	289.6	333.0	449.0	712.0
44.	2025012	15	2	103.9	132.4	155.2	146.4	195.1	261.0	451.0
			5	147.9	203.7	224.2	211.5	257.7	343.0	599.0
			10	176.9	250.9	269.9	254.6	299.1	397.0	698.0
			20	205.0	296.1	313.7	295.9	338.8	449.0	792.0
45.	2029001	24	2	115.7	146.0	181.5	216.5	273.0	399.0	616.0
			5	146.6	191.2	229.0	273.5	355.0	509.0	743.0
			10	167.1	221.1	260.3	311.3	409.0	582.0	827.0
			20	186.7	249.7	290.5	347.5	461.0	652.0	908.0
46.	2112027	14	2	197.7	228.3	252.4	293.6	339.0	492.0	687.0
			5	254.7	297.0	335.2	400.4	457.0	658.0	846.0
			10	292.4	342.5	390.0	471.1	534.0	768.0	951.0
			20	328.7	386.1	442.6	539.0	609.0	874.0	1,052.0
47.	2115008	13	2	125.74	150.6	176.2	201.1	236.0	327.0	524.0
			5	162.3	209.1	265.3	305.2	295.0	409.0	639.0
			10	186.5	247.9	324.4	374.1	334.0	463.0	716.0
			20	209.7	285.0	381.0	440.3	372.0	515.0	789.0
48.	2116030	14	2	133.7	158.7	180.3	210.0	242.5	336.7	549.0
			5	168.2	198.4	213.3	249.8	279.9	403.1	665.1
			10	191.0	224.6	235.1	276.1	304.6	447.0	741.9
			20	212.7	249.8	256.1	301.4	328.3	489.2	815.7

APPENDIX B—*(cont.)*

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
49.	2218017	31	2	132.4	151.3	176.3	204.4	245.0	328.0	540.0
			5	172.9	190.5	222.7	254.6	305.0	421.0	684.0
			10	199.8	216.5	253.4	287.8	345.0	483.0	778.0
			20	225.7	241.5	282.9	319.7	383.0	543.0	869.0
50.	2231043	12	2	140.3	180.5	218.4	244.1	281.1	382.0	615.0
			5	206.5	297.9	348.5	408.3	471.1	632.0	1,024.0
			10	250.3	375.7	434.7	516.9	596.8	797.0	1,295.0
			20	292.3	450.4	527.5	621.2	717.5	955.0	1,891.0
51.	2318007	25	2	120.4	149.1	171.2	206.0	243.0	359.0	535.0
			5	146.5	176.4	198.5	244.0	287.0	427.0	624.0
			10	163.8	194.4	216.7	269.0	316.0	472.0	683.0
			20	180.3	211.7	234.0	293.0	344.0	515.0	740.0
52.	2320059	8	2	127.2	175.2	201.4	238.0	281.0	392.0	634.0
			5	171.7	235.9	288.4	339.0	375.0	506.0	762.0
			10	201.2	275.9	346.0	407.0	437.0	581.0	847.0
			20	229.5	314.5	401.2	471.0	497.0	653.0	929.0
53.	2325039	12	2	124.5	173.3	220.5	273.8	328.6	508.0	819.0
			5	151.4	225.0	294.6	385.4	478.2	707.0	1,154.0
			10	169.1	259.2	343.5	459.2	577.2	838.0	1,375.0
			20	186.2	292.0	390.6	530.1	672.3	964.0	1,587.0
54.	2333044	6	2	132.5	172.3	199.4	249.5	309.8	443.7	733.0
			5	163.8	202.7	243.8	308.9	365.6	594.9	979.0
			10	184.6	223.0	273.2	348.2	402.5	695.0	1,142.0
			20	204.5	242.4	301.4	385.9	437.9	791.0	1,299.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

b) Manual Station (Sarawak)—*(cont.)*

No.	Station Number	Length of Record (n)	Return Period (T)	Duration (t) Days						
				1	2	3	5	7	14	30
85.	3950020	13	2	129.3	160.9	192.3	238.4	288.9	417.0	660.0
			5	167.0	200.9	228.5	311.2	382.0	618.0	955.0
			10	192.0	227.4	252.5	359.4	443.7	752.0	1,150.0
			20	216.0	252.8	275.5	405.7	502.9	879.0	1,338.0
86.	4038006	25	2	155.8	168.3	217.8	245.0	276.0	370.0	552.0
			5	229.0	293.0	363.3	407.0	451.0	585.0	795.0
			10	277.5	361.4	459.6	514.0	568.0	727.0	956.0
			20	324.0	426.9	552.0	617.0	679.0	864.0	1,110.0
87.	4039019	6	2	124.6	162.3	190.3	211.0	221.0	307.3	461.6
			5	201.0	244.6	316.1	328.0	344.6	457.2	621.8
			10	251.6	299.2	399.4	405.5	426.3	556.4	727.8
			20	300.2	351.4	479.4	479.9	504.8	651.6	829.6
88.	4139047	8	2	117.6	143.0	171.3	194.1	212.0	308.3	465.0
			5	154.4	176.5	248.6	271.7	297.5	421.2	624.4
			10	178.8	198.6	299.7	323.1	354.1	496.0	730.0
			20	202.1	219.9	348.7	372.5	408.4	567.8	831.3
89.	4143004	19	2	141.0	174.6	197.8	231.0	266.0	358.0	560.0
			5	270.5	365.5	418.4	485.0	531.0	658.0	954.0
			10	356.3	491.7	564.5	653.0	706.0	856.0	1,214.0
			20	438.4	612.9	704.7	815.0	874.0	1,046.0	1,464.0
90.	4255006	23	2	72.6	100.0	120.8	149.9	190.0	266.0	407.0
			5	87.1	117.3	140.1	176.5	223.0	325.0	469.0
			10	96.7	128.7	152.9	194.2	245.0	364.0	509.0
			20	105.9	139.8	165.1	211.1	266.0	401.0	549.0

RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) Manual Station (Sarawak)—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
91.	4239048	9	2	143.6	182.3	211.0	233.9	269.2	369.0	562.0
			5	199.3	271.1	328.4	395.4	456.2	683.0	1,223.0
			10	236.0	329.8	406.1	502.4	580.5	891.0	1,661.0
			20	271.3	386.2	480.7	605.0	699.5	1,091.0	2,081.0
92.	4339005	32	2	151.2	182.7	200.4	228.3	259.0	350.0	518.0
			5	210.4	253.7	291.4	353.1	429.0	567.0	777.0
			10	249.8	300.6	351.5	435.7	542.0	711.0	948.0
			20	287.4	345.7	409.3	515.0	650.0	850.0	1,113.0
93.	4440001	25	2	165.1	197.4	221.2	247.0	285.0	399.0	598.0
			5	235.0	279.4	312.6	374.0	470.0	688.0	963.0
			10	281.2	333.6	373.0	457.0	593.0	879.0	1,205.0
			20	325.7	385.7	431.1	537.0	710.0	1,062.0	1,437.0
94.	4449012	15	2	139.8	170.9	206.9	247.6	300.6	434.3	674.0
			5	171.7	204.3	252.4	306.2	379.9	569.4	836.0
			10	192.9	226.6	282.5	345.1	432.4	654.9	943.0
			20	213.2	247.9	311.4	382.3	482.8	744.7	1,046.0
95.	4548004	28	2	137.4	177.8	209.4	243.0	286.0	405.0	630.0
			5	189.9	235.1	275.4	311.0	368.0	526.0	774.0
			10	224.7	273.1	319.1	356.0	423.0	606.0	869.0
			20	258.0	309.6	361.0	399.0	475.0	683.0	960.0
96.	4650007	21	2	141.7	181.0	210.7	243.0	304.0	469.0	692.0
			5	184.7	231.9	263.0	287.9	336.0	536.0	801.0
			10	213.2	265.5	297.6	317.6	357.0	587.0	874.0
			20	240.4	297.8	330.9	346.2	377.0	635.0	943.0

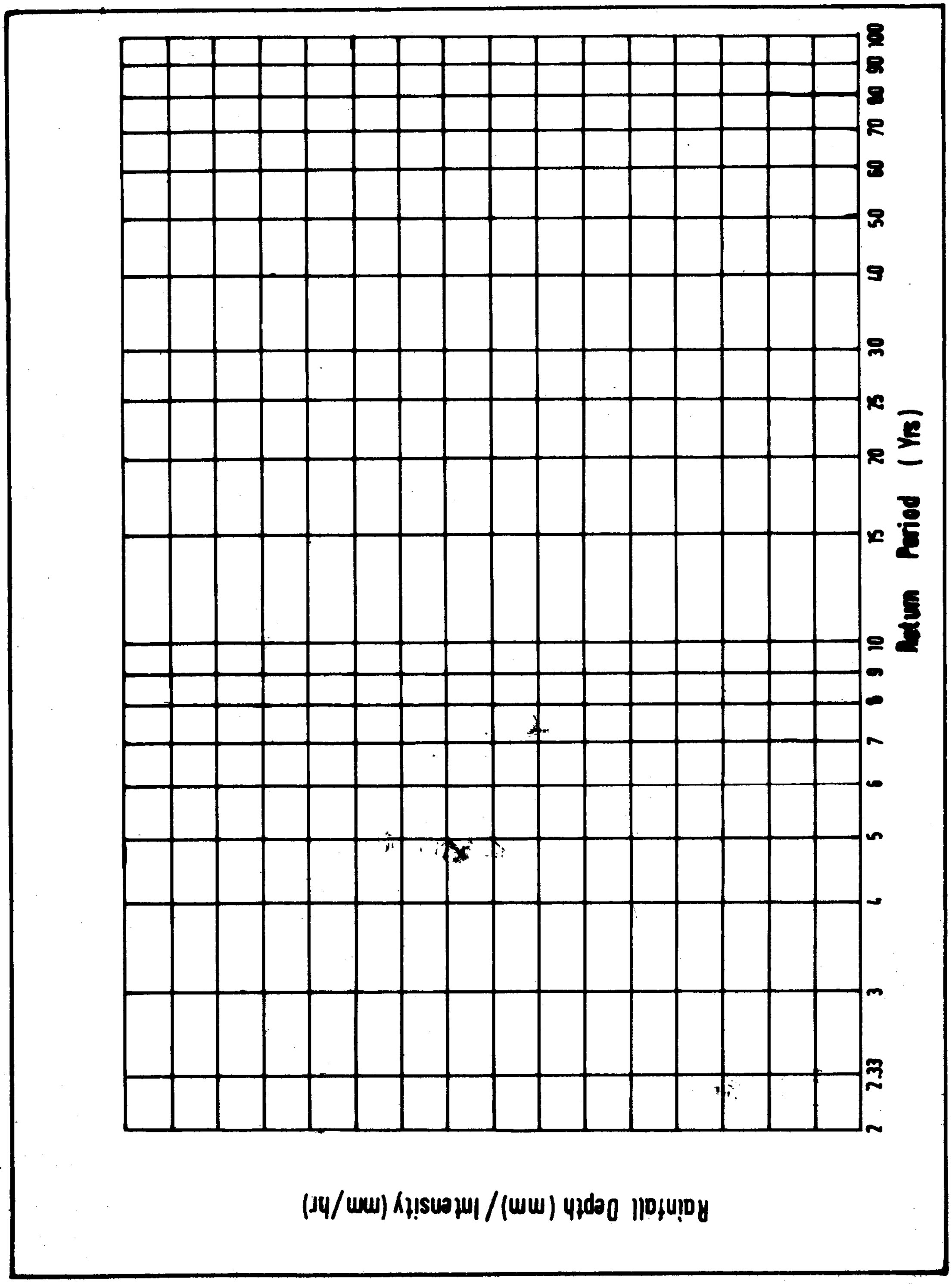
RESULTS OF GUMBEL FREQUENCY ANALYSIS OF RAINFALL DEPTHS FOR VARIOUS RETURN PERIODS AND DURATIONS IN MM.—(cont.)

(b) **Manual Station (Sarawak)**—*(cont.)*

No.	*Station Number*	*Length of Record (n)*	*Return Period (T)*	*Duration (t) Days*						
				1	*2*	*3*	*5*	*7*	*14*	*30*
97.	4749010	14	2	162.6	199.5	237.9	266.7	289.1	427.0	657.0
	(Limbang Pumphouse)		5	206.5	279.2	344.9	366.7	405.8	569.0	866.0
			10	235.5	332.0	415.8	432.9	483.1	663.0	993.0
			20	263.3	382.8	484.0	496.4	557.3	753.0	1,114.0
98.	4752022	7	2	188.2	250.5	275.4	356.2	406.5	588.0	767.0
			5	267.3	376.8	431.3	554.8	636.1	916.0	1,335.0
			10	319.8	460.4	534.6	686.3	788.0	1,134.0	1,711.0
			20	370.0	540.6	633.6	812.5	933.9	1,342.0	2,072.0
99.	4852002	14	2	140.2	151.4	219.4	259.4	286.0	402.0	606.0
			5	198.6	255.5	304.9	382.3	431.0	621.0	893.0
			10	237.2	297.2	361.5	463.7	527.0	766.0	1,083.0
			20	274.4	337.2	415.7	541.8	620.0	906.0	1,266.0
100.	4854003	28	2	137.6	189.3	216.8	253.3	269.5	399.3	609.0
			5	193.6	275.3	302.9	341.0	363.2	509.7	773.0
			10	230.7	332.2	360.0	399.1	425.2	582.8	881.0
			20	266.3	386.9	414.7	454.9	484.7	653.0	785.0
101.	4955021	6	2	162.3	198.7	213.1	248.3	306.2	420.7	627.9
			5	208.1	240.6	262.0	300.1	393.1	499.6	790.0
			10	238.5	268.5	294.5	334.4	450.6	551.7	897.0
			20	267.2	295.2	325.6	367.3	505.8	601.8	1,000.3

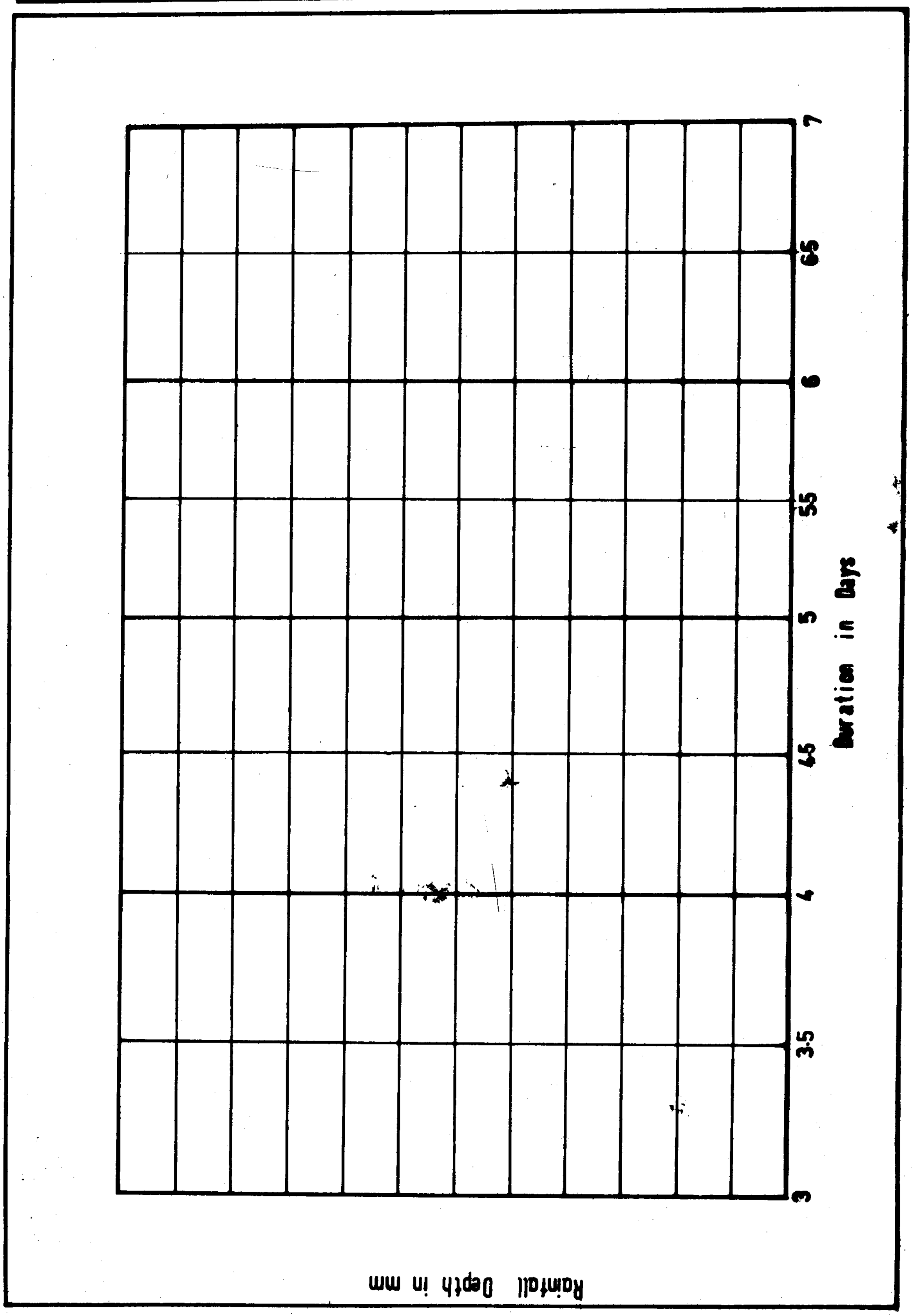
APPENDIX C

SAMPLE OF RAINFALL DEPTH/INTENSITY RETURN PERIOD PLOTTING DIAGRAM



APPENDIX D

SAMPLE OF RAINFALL DEPTH—DURATION PLOTTING DIAGRAM



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