HYDROLOGICAL PROCEDURE NO. 16

FLOOD ESTIMATION FOR URBAN AREAS IN PENINSULAR MALAYSIA

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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Bahagian Parit dan Taliair

Kementerian Pertanian

ACKNOWLEDGEMENTS

The work reported here has been carried out by the Urban Drainage Unit of the Drainage and Irrigation Department in association with Sinclair Knight & Partners Pty Ltd Consulting Engineers.

(Reprint: 1980)

Published by and available from:

Publications Unit, Ministry of Agriculture

Jalan Swettenham, Kuala Lumpur.

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1. INTRODUCTION

In December 1975, Planning and Design Procedure No 1 titled, "Urban Drainage Design Standards and Procedures for Peninsular Malaysia", (1), was published by the Drainage and Irrigation Division of the Ministry of Agriculture and Rural Development, Malaysia.

All the Standards and most of the Procedures contained in the Publication were based on recognised current overseas practice in urban drainage design and were established following an extensive review of overseas and local literature. The Flood Estimation Procedure however, was developed by the Urban Drainage Unit of the Drainage and Irrigation Department.

This Paper develops the Flood Estimation Procedure recommended for use in urban areas in Peninsular Malaysia and serves as a technical support volume for the earlier publication. Results of the developed procedure are compared with other flood estimation techniques in sample catchments in the Kuala Lumpur Conurbation.

2. REQUIREMENTS OF THE PROCEDURE

It is required that the flood estimation procedure satisfy the following conditions:

1. Estimate design peak discharges for urban catchments in Peninsular Malaysia for various:
   - Return Periods
   - Degrees of urban development
   - Catchment areas up to 20 square miles.
2. Where necessary produce a hydrograph corresponding to the peak discharge.
3. Utilise input data which can be readily determined from topographic and land use maps.
4. Be capable of simple hand calculation.

Of all the flood estimation procedures reviewed, the Rational Method provided the most suitable means of achieving the above requirements. It was realised however that this procedure overestimates the peak discharge for large catchments (over 200 acres), because it does not take into account areal and temporal variation in storm rainfall, and detention storage present in surface depressions, gutters, and channels.

In the development of the recommended flood estimation procedure it was not considered either necessary or possible (due to lack of local data) to reduce the peak design discharge for the areal and temporal variation in the storm rainfall, and this has been neglected in the procedure. It was however considered necessary to account for detention storage effects of the larger catchments, particularly because most drainage systems are open channel with considerable storage capacity.

The following section of this Paper develops the recommended procedure, a Modified Form of the Rational Method, by briefly discussing the important parameters in the Standard Rational Method and developing a simple coefficient which when applied to the Standard Rational Method can account for the effects of detention storage.

3. DEVELOPMENT OF THE PROCEDURE

3.1 General

The Standard Rational Method is usually expressed in terms of the following equation:

$$Q = C\ I\ A \tag{3.1}$$

where Q is the peak discharge in cusecs, C is the runoff coefficient depending on the characteristics of the drainage area, I is the uniform rate of rainfall intensity in inches per hour for a duration equal to the time of concentration, and A is the drainage area in acres. The time of concentration, t_c is defined as the time which would be required for the surface runoff from the most remote part of the catchment to reach the point being considered and is the sum of the overland flow time, t_o and the time of flow in the drain, t_d.

$$t_c = t_o + t_d \tag{3.2}$$

To account for channel storage, an additional coefficient, C_s, has been added to obtain the Modified Form of the Rational Method as follows:

$$Q = C_s\ C\ I\ A \tag{3.3}$$

where $$C_s = \frac{2t_c}{2t_c + t_d} \tag{3.4}$$

A discussion of the important parameters in the Standard Rational Method: the runoff coefficient, C, the rainfall intensity, I, and the time of concentration t_c, together with the development of the storage coefficient, C_s, follows.

3.2 Runoff Coefficient, C

The choice of the value of C is the most intangible aspect in the use of the Rational Method. Taken literally, it represents the multiplier of a 100 percent runoff peak (assuming no infiltration or storage) required to obtain the design peak. This coefficient has to account for the various climatic conditions and physiographic characteristics of the catchment.

One approach for establishing the value of C, that has received much discussion in literature recently, (2, 3, 4), has been by the statistical approach. This approach defines C as the ratio of the flood discharge per unit area, for a certain return period, to the peak rainfall intensity for that return period. The respective discharge and rainfall intensity are obtained from separate frequency analyses of annual flood peaks, and annual rainfall peaks for a duration equal to the time of concentration. The particular discharge and rainfall intensity whose ratios are taken are not necessarily derived from the same flood event.

The advantage of this approach is that the runoff coefficient accounts for areal and temporal variation of storm rainfall and detention storage. However to adopt this approach requires extensive local rainfall and stream gauging records. Whilst the rainfall records generally exist, there are few urban catchments with gauging stations in the world and none in Peninsular Malaysia.

Another approach in determining the runoff coefficient is to assume that C is equal to the proportion of the catchment area which is impervious and directly connected to the drainage network. Implicit in this concept is that runoff from the remaining area, i.e. pervious areas and impervious areas not directly connected to the drainage network, is ignored. This assumption is satisfactory under the following conditions as has been demonstrated by Aitken (2).

1. Area of low rainfall intensity.

2. Areas of moderate rainfall intensity but in which the heavier falls occur when antecedent conditions are dry.

3. Areas with porous soils.

4. Areas with Average porosity soils and very flat slopes.

These conditions do not normally exist in the large urban centres of Peninsular Malaysia and it is considered that runoff from the pervious areas should be taken into account.

The most universal approach for design engineers, and the one recommended in this procedue is to use runoff coefficients based on the type of land use. Several sources have been investigated for suitable runoff coefficients to be used in Malaysian drainage design, and these are outlined in Appendix A. The recommended values are shown in Table 3.1.

Table 3.1 Runoff Coefficients for Urban Centres

Land Use	Runoff Coefficient
Business:–	
City Areas Fully built-up and Shophouses	0.90
Industrial:–	
Fully built-up	0.80
Residential:–	
4 houses/acre	0.55
4 – 8 houses/acre	0.65
8 – 12 houses/acre	0.75
12 houses/acre	0.85
Pavement	0.95
Parks (normally flat in urban areas)	0.30
Rubber	0.45
Jungle (normally steep in urban areas)	0.35
Mining land	0.10

For fully built-up city and industrial areas most sources were in close agreement and values of 0.9 and 0.8 were adopted respectively. For pavements and parks, standard values as recommended in most of the literature have been adopted. Useful guides for values of C for rubber and jungle were obtained from Heiler (4) and AUSTEC (5), and the recommended values are in close agreement with these sources. For residential areas the literature showed a wide variation in values, due mainly to the different types of residential development. To ascertain lower limits, the percent imperviousness of various types of development were analysed. The work was carried out on subdivision maps of Kuala Lumpur and the results are shown in Table 3.2.

Table 3.2 Percent Imperviousness as a Function of Land Use

Development	Housing Density (houses/acre)	Imperviousness (percent)
Terraced houses	13.4	80
	14.6	85
Semi-detached houses	5.7	52
	7.9	62
Detached bungalows	2.9	41

To determine recommended values of C, an allowance for the pervious areas was added to the above figures based on a qualitative assessment of the runoff coefficients presently in use.

It will be noted that no variation in C is recommended for changes in rainfall intensity as is done in Australian Rainfall and Runoff, (6). This is because the operation of varying C in urban drainage design is tedious and cumbersome and is not considered warranted.

3.3 Rainfall Intensity, I

The method of estimating the design rainstorm (and hence rainfall intensities) is contained in DID Hydrological Procedure No 1, (7), and relationships for major urban areas in Peninsular Malaysia are published in the Urban Drainage Design Standards and Procedures for Peninsular Malaysia, (1). The Rainfall Intensity-Duration-Frequency Relationship for Kuala Lumpur, Figure 3.1 is included in this Paper as an example and will be used later in this Paper in testing the procedure.

To determine the appropriate rainfall intensity it is necessary to estimate the duration of rainfall, which in the Rational Method is the time of concentration, t_c.

3.4 Time of Concentration, t_c

A review of the literature revealed many empirical formulas for estimating the time of concentration. Most however are based on local conditions. For urban areas in Peninsular Malaysia it is recommended that the time of concentration be estimated from the sum of the overland time, t_o, and the time of flow in the drain, t_d.

$$t_c = t_o + t_d \qquad (3.2)$$

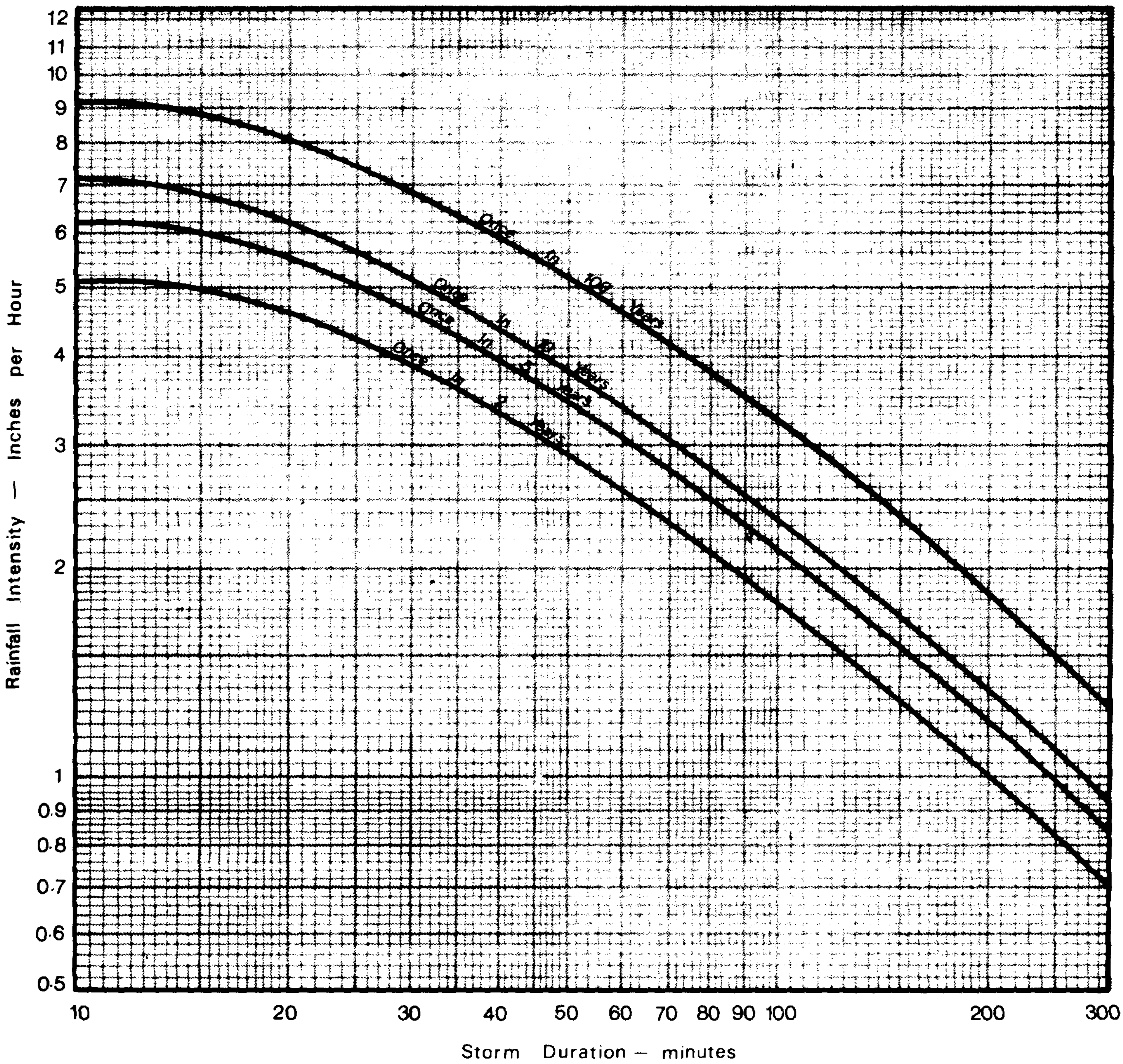

Figure 3 — 1 Rainfall Intensity — Duration — Frequency Relationship — Kuala Lumpur

It is recommended that the Rantz extension (8) of the Wright McLaughlin chart (9) be used for overland flow time (t_o) estimation. This requires a knowledge of the runoff coefficient, C and the overland flow length and slope. For areas for which these parameters cannot be determined such as an area yet to be mapped out, an overland flow time of 10—15 minutes can be assumed. The Rantz chart is shown in Figure 3.2.

The time of flow in the drain (t_d) can be determined from normal hydraulic formulas, given the channel cross section, length, roughness and slope. In areas yet to be mapped out t_d can be determined by dividing the estimated drain length by 10 ft/sec for proposed lined drains or by the average velocities indicated in Table 3.3. (Note that these velocities are for natural streams.)

3.5 Storage Coefficient, C_s

(a) General

To simulate basin storage, a Rational Method hydrograph formed by the time-area diagram of a catchment can be routed through a hypothetical basin reservoir at the design point. In addition, by adopting a conservative approach to the Muskingum Routing Equation, it can be assumed that the relationship between basin storage and the discharge is of the form:

$$S = KO \qquad (3.5)$$

where S is the storage volume, O is the discharge from the storage area, and K is a storage delay time constant.

The determination of the proper value of K is the uncertainty in the procedure.

(b) Determination of Storage Delay Time Constant, K

(i) Aitken — Aitken, (II), analysed six urban catchments in Australia with essentially the same method as described above and adopted a K value equal to $0.3t_c$. This procedure he termed the Clarke Model A. He compared the hydrograph obtained in his six catchments with the Rational Method hydrographs (using the time-area diagram), and with the Road Research Laboratory Method hydrographs, (12).

Aitken found that the Rational Method over-estimated the observed peak discharge whilst the Clarke Model A and the RRL Methods both gave good agreement with the observed values. Aitken preferred the Clarke Model A to the RRL Method however because the routing was linear, and therefore simple, and because the need to compute a non-linear storage relationship by calculating volumes of storage in pipes was obviated.

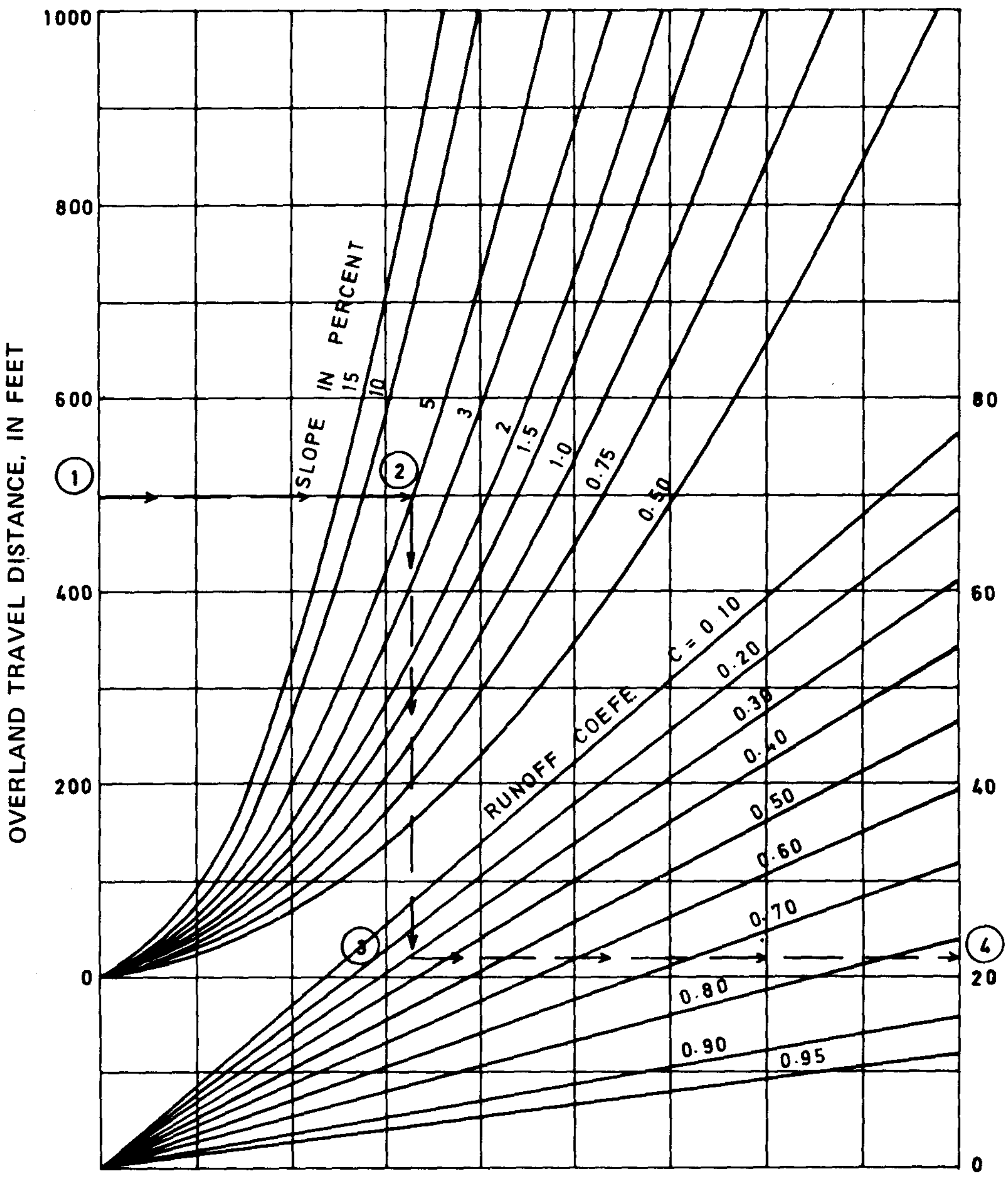

Figure 3.2 Design Chart for Estimation of Overland Time of Flow

Table 3.3 Approximate Stream Velocities (10)

Average Slope of Channel (percent)	Average Velocity (feet/second)
1–2	2.0
2–4	3.0
4–6	4.0
6–10	5.0
10–15	8.0

A further simplification was introduced by taking the ratio of the peak discharges estimated by the Clarke Model A to those estimated by the Rational Method. He found that the reduction in peak discharge over that given by the Rational Method depended on the shape of the time-area diagram. The relationship shown in Figure 3.3 was arrived at, by taking C_s – a storage coefficient – as the ratio of the Clarke Model A discharges to the Rational Method discharges.

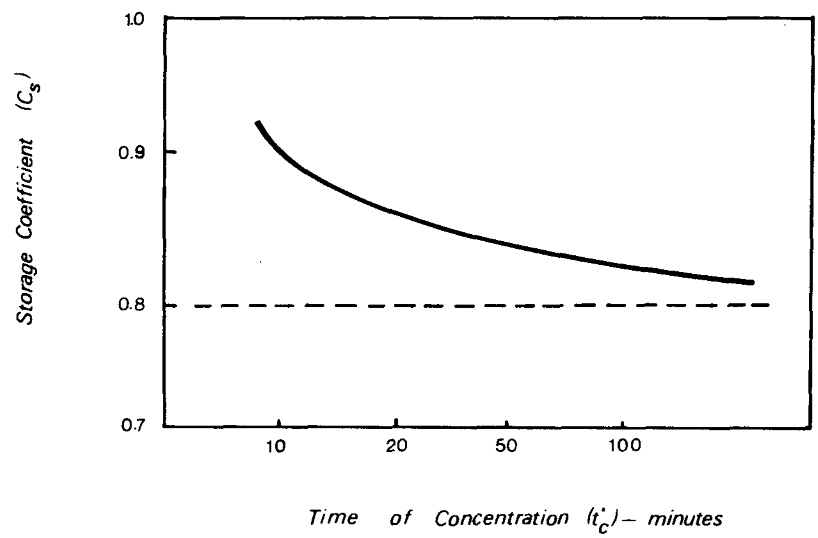

Figure 3.3 Storage Coefficient Curve – By Aitken (K = 0.3t_c)

C_s reached a minimum value of 0.8 for either large catchments or those with straight line time-area diagrams. Smaller catchments with lower values of t_c tended to have "S" shaped time-area diagrams and as a consequence higher values of C_s. In fact it can be shown by a finite method, that the minimum value of C_s is directly related to the ratio of the storage delay time constant chosen, to the time of concentration. The minimum values are achieved, either with inflow hydrographs with straight line time-area diagrams or from large catchments. The minimum values of C_s from a finite method analysis are shown in Table 3.4.

Table 3.4 Minimum Values of Storage Coefficient, C_s

Storage Delay Time Constant (K) (proportion of t_c)	1.00	.90	.80	.70.	.60	.50	.40	.30	.20	.10
Minimum Values of Storage Coefficients (C_s)	.50	.54	.57	.61	.65	.68	.74	.80	.86	.93

(ii) *Linsley, Kohler and Paulhus* – Linsley, Kohler and Paulhus (LKP) (13) described a lag and route procedure to simulate basin storage, where the lag time was taken as the time of flow in the drain (t_d). The Muskingum Method with K = lag and x = 0 (ie. a concentrated linear storage) was used for storage routing and this was claimed to be conservative.

The use of $K = t_d$ for large catchments is closely equivalent to $K = t_c$ as the effect of overland flow time (t_o) diminishes. LKP used what was essentially a Rational Method triangular hydrograph as the inflow to the catchment storage which is equivalent to assuming a straight line time-area diagram. Table 3.4 has indicated that for $K = 1.0t_c$, the attenuation of the hydrograph formed by a straight line time-area diagram is $C_s = 0.50$ which is close to the peak reduction achieved by LKP in their method which used $K = 1.0t_d$.

A significant advantage in using K as a proportion of the time in the drain is that as the catchment gets larger, t_d approaches t_c and the storage coefficient approaches a minimum. Conversely as the catchment gets smaller, t_d is a small proportion of the total time of concentration and the storage coefficient approaches 1.0, (see Table 3.4). This is desirable as it was intended that the procedure should approach the Standard Rational Method for the smaller catchments but also to account for basin storage for the larger catchments.

(iii) *Conclusions* – The work by Aitken was carried out in Australian catchments where the storage was related to the capacity of the drainage pipes. These were compared to the RRL method which also relates the storage to the capacity of the pipes. In Malaysian conditions the storage capacity in open channels is considered greater than in closed pipe systems generally because average velocities are lower thereby requiring larger cross-section areas (and hence larger volumes) for similar discharges. It is therefore considered that the value of $K = 0.3t_c$ which gives a minimum storage coefficient of $C_s = 0.8$ is too conservative. It is also considered that the minimum storage coefficient of $C_s = 0.5$ achieved by the LKP Method with $K = 1.0t_d$ is too low to use without substantive data. It was therefore decided to take the middle course and adopt a minimum value of $C_s = 0.67$, which from Table 3.4 is equivalent to having a storage delay time constant, $K = 0.5t_c$. It was further decided that to ensure the storage coefficient would approach 1.0 for the smaller catchments and 0.67 for the larger catchments that the storage delay time constant should be set equal to $0.5t_d$, and this value has been adopted for further study.

(c) *Simplified Form of the Storage Coefficient, C_s*

One requirement of the flood estimation procedure was that it be capable of simple hand calculation. It was therefore necessary to develop a simple formula for C_s that would eliminate the tedious flood routing. It was further necessary that the formula would develop a minimum value of 0.67 for large catchments and approach 1.0 for small catchments.

A guide to the form of the equation was found in the procedure used by the City of Philadelphia, Chow (14). It was found in the Philadelphia Inlet Method that a factor, F_t' could be applied to a version of the Rational Method to account for detention storage.

$$F_t' = \frac{2T}{2T + .8L/V} \qquad (3.6)$$

In the above equation T is the time from the beginning of intense rainfall to the end of the period of maximum rainfall intensity, L is the length of the drain from the inlet to the design point, and V is the mean velocity of flow in the drain.

The approach in this procedure was to let T equal the time of concentration, t_c, and .8L/V be equivalent to the time in the drain, t_d. The storage coefficient equation then reduces to:

$$C_s = \frac{2t_c}{2t_c + t_d} \qquad (3.4)$$

which for larger catchments where t_d approaches t_c is equivalent to $C_s = 0.67$ and for small catchments where t_d is very small compared to t_c, the value of C_s approaches 1.0. This equation therefore satisfies the two required end conditions and is also simple to use.

3.6 Comparison of Procedures

To test the validity of using a storage coefficient, C_s, in lieu of the more elaborate routing procedure, a comparison was made between the two procedures for four catchments in the Kuala Lumpur Conurbation. The results were also compared to those obtained by the Standard Rational Method. The details of the various catchments investigated are shown in Table 3.5, and the results of the investigation are shown in Table 3.6.

Table 3.5 Details of the Catchments Investigated

Catchment	A	B	C	D
Area, A (acres)	46	223	1013	4010
Runoff Coefficient, C	.75	.60	.45	.40
Design Return Period, T (years)	5	5	5	5
Drain Length, L (feet)	1460	4375	9140	29,815
Average Drain Velocity, V (ft/sec)	8	6	5	5
Drain Time, t_d (min)	3	12	30	99
Overland Time, t_o (min)	10	10	10	10
Time of Concentration, t_c (min)	13	22	40	109
Rainfall Intensity, I (inches/hr)	5.85	5.3	3.95	2.0

Table 3.6 Comparison of Results

Procedure	Design Discharge (cusecs) for Catchments A	B	C	D
Rational Method ($Q = CIA$)	202	710	1800	3210
Routing Procedure with $K = .5t_d$	178	584	1359	2262
Modified Rational Method ($Q = C_sCIA$) where $C_s = \dfrac{2t_c}{2t_c + t_d}$	180	554	1314	2215

It can be seen from the above Table that the values obtained for the Modified Rational Method are in close agreement with those obtained by the more elaborate routing procedure. It was therefore concluded that the Modified Rational Method with $C_s = 2t_c/(2t_c + t_d)$ is acceptable for use.

3.7 Design Hydrograph

In the occasional situation where a flood hydrograph is required, such as for detention storage, a Modified Rational Method hydrograph can be developed based on the following assumptions:

1. The peak discharge is equal to C_sCIA.
2. The area under the modified hydrograph (volume of water) is the same as for the Standard Rational Method hydrograph.

By setting b = base of the modified hydrograph, then

$$\frac{1}{2}(b)\ (C_sCIA) = \frac{1}{2}(2t_c)(CIA)$$

$$b = \frac{2t_c}{C_s}$$

by substituting $2t_c/(2t_c + t_d)$ for C_s then

$$b = 2t_c + t_d \qquad (3.7)$$

The problem then remains to proportion the base of the hydrograph (b) between the rising and recession limbs. To be conservative it was decided to set the rising limb equivalent to the time of concentration, t_c, leaving the recession limb equivalent to $t_c + t_d$. This has been done and the results are shown in Figure 3.4.

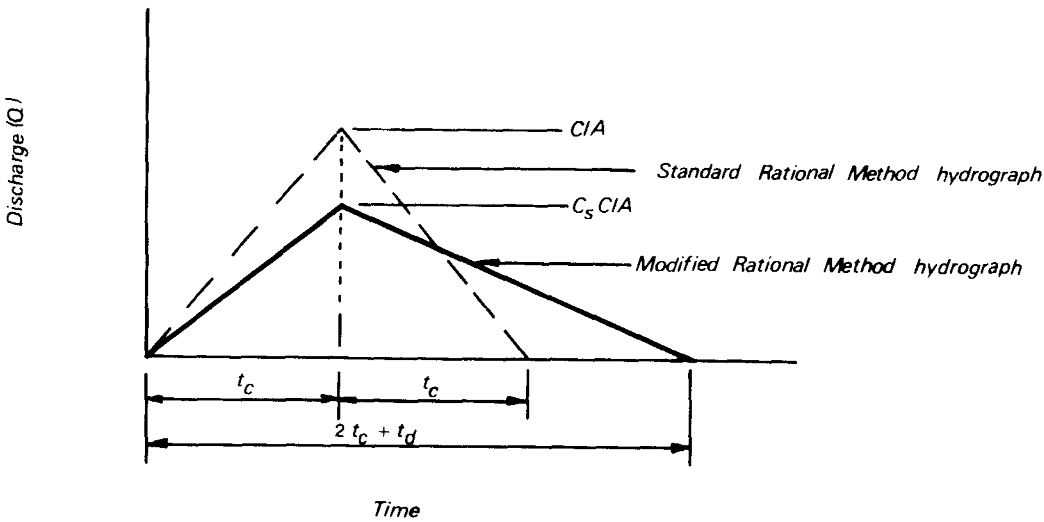

Figure 3.4 Modified Ration Method Hydrograph

4. CONCLUSIONS

A flood estimation procedure has been formulated which embodies the straight-forward concepts of the Rational Method. The procedure incorporates an additional parameter which makes an allowance for the channel storage effects which are significant in large urban areas in Peninsular Malaysia. The procedure is essentially empirical in nature and does not lay claim to being a conceptual model of the runoff process.

The procedure is considered to be applicable to the drainage design of urban catchment areas of up to 20 square miles.

5. USE OF THE PROCEDURE

The use of the procedure is illustrated in the following worked example.

5.1 Problem

A 5 year design discharge is required for a culvert in a catchment in Kuala Lumpur with the following characteristics.

Area (A)	650 acres
Average Runoff Coefficient (C)	0.65
Overland Travel Distance (L_o)	500 feet
Overland Slope (S_o)	5 percent
Overland Runoff Coefficient (C_o)	0.3
Stream Length to Design Point (L)	3000 feet
Average Stream Slope (S)	5 percent

5.2 Solution

The Five Year Design Discharge $Q_5 = C_s\ C\ I_5\ A$

(a) Step 1 – Overland Time, t_o

From Figure 3.2, with $L_o = 500$ feet, $S_o = 5$ percent, $C_o = 0.3$, $t_o = 22$ minutes

(b) Step 2 – Drain Time, t_d

With L = 3000 feet and Velocity = 4 feet/second (from Table 3.3 for S = 5 percent), $t_d = (3000) / (4 \times 60)$ minutes = 12.5 minutes.

(c) Step 3 – Time of Concentration, t_c

From equation 3.2, $t_c = 22 + 12.5 = 34.5$ minutes.

(d) *Step 4 – Storage Coefficient, C_s*

From equation 3.4, $C_s = (69/81.5) = 0.85$

(e) *Step 5 – Rainfall Intensity, I*

With t_c = 34.5 minutes from Figure 3.1, I_5 = 4.2 inches/hour

(f) *Step 6 – Design Charge, Q_5*

$Q_5 = (0.85)\ (0.65)\ (4.2)\ (650)$ cusecs, Q_5 = 1508 cusecs.

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APPENDIX A

COMPARISON OF RUNOFF COEFFICIENTS FROM VARIOUS SOURCES.

This Appendix contains tables of runoff coefficients that were used to varying degrees in determining the recommended values as shown in Table 4.1 of the text.

Table A–1 C Values Used By JPT (15)

Type of Drainage Area	Coefficient C
Business Areas	0.70 – 0.95
Residential Areas	0.25 – 0.50
Light Industrial Areas	0.50 – 0.80
Unimproved Areas	0.10 – 0.30
Streets	0.70 – 0.95
Lawns:	
Sandy soil, flat 2%	0.05 – 0.10
Sandy soil, av. 2 – 7%	0.10 – 0.15
Sandy soil, steep 7%	0.15 – 0.20
Heavy soil, flat 2%	0.13 – 0.17
Heavy soil, av. 2 – 7%	0.18 – 0.22
Heavy soil, steep 7%	0.25 – 0.35

Table A–2 C Values Used By PKNS

Type of Drainage Area	Coefficient C
Highly built-up areas	0.8 – 0.9
Terrace lots	0.7 – 0.75
Detached bungalow lots	0.5 – 0.6
Flat open areas	0.2 – 0.3

Table A–3 C Values Recommended By Proctor and Redfern (16)

Land Use	Unmined Land	
	Flat	Steep
2 Houses/Acre	0.10	0.15
2 Houses/Acre	0.14	0.19
3 Houses/Acre	0.17	0.22
4 Houses/Acre	0.20	0.25
5 Houses/Acre	0.22	0.27
6 Houses/Acre	0.25	0.30
7 Houses/Acre	0.27	0.32
8 Houses/Acre	0.32	0.37
12 Houses/Acre	0.42	0.47
15 Houses/Acre	0.50	0.55
Multiple Family Flats or Apartments	0.65	0.70
Shophouses	0.80	0.80
Commercial	0.80	0.90
Industrial (Light)	0.60	0.65
Institutional	0.40	0.45
Open Space	0.10	0.15
Rubber	0.15	0.20
Jungle	0.10	0.15
Fully Paved Areas	0.90	0.90
Tin Mining Land	0.10	0.10

Table A–4 C Values Used By The Ministry of Environment Singapore

Characteristic of the catchment when fully developed	Value of C		
	Average slope less than 1 in 100	Average slope 1 in 20 to 1 in 100	Average slope greater than 1 in 20
Roofs connected direct to channel or drain	–	0.95	–
Asphalt and dense pavements	–	0.95	–
City areas fully and closely built	0.85	0.90	0.95
Densely built residential areas	0.75	0.80	0.85
Residential districts not densely built-up	0.60	0.65	0.70
Rural areas with fish ponds and vegetable gardens	0.40	0.45	0.50

Table A–5 C Values Recommended By AUSTEC (5)

Ultimate Land Use	Runoff Coefficient
Impervious Areas – City areas both fully and solidly built up	0.9
Detached Houses in Urban Areas	0.6
Rubber, Oil Palm, Secondary Jungle, Average Grassed or Medium-Timbered Land	0.5
Primary Jungle or Forest	0.4
Flat Grass Areas	0.3
Padi Areas	Determined by Capacity of outlet from Padi Scheme

Table A–6 C Values Recommended by ASCE (17)

Description of Area	Runoff Coefficient
Business	
Downtown	0.70 to 0.95
Neighbourhood	0.50 to 0.70
Residential	
Single-family	0.30 to 0.50
Multi-units, detached	0.40 to 0.60
Multi-units, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved	0.10 to 0.30
Character of Surface	
Pavement	
Asphaltic and Concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, sandy soil	
Flat, 2 percent	0.05 to 0.10
Average, 2 to 7 percent	0.10 to 0.15
Steep, 7 percent	0.15 to 0.20
Lawns, heavy soil	
Flat, 2 percent	0.13 to 0.17
Average, 2 to 7 percent	0.18 to 0.22
Steep, 7 percent	0.25 to 0.35

PROCEDURES PREVIOUSLY PUBLISHED

No. 1 -	Estimation of the Design Rainstorm (1973)	$8.00
No. 2 -	Water Quality Sampling for Surface Water (1973)	$3.00
No. 3 -	A General Purpose Event Water-Level Recorder Capricorder Model 1598 (1973)	$5.00
No. 4 -	Magnitude and Frequency of Floods in Peninsular Malaysia (1974)	$6.00
No. 5 -	Retional Method of Flood Estimation for Rural Catchments (1974)	$3.00
No. 6 -	Hydrological Station Numbering System (1974)	$3.00
No. 7 -	Hydrological Station Registers (1974)	$5.00
No. 8 -	Field Installation and Maintenance of Capricorder 1599 (1974)	$5.00
No. 9 -	Field Installation and Maintenance of Capricorder 1598 Digital Event Water Level Recorder (1974)	$5.00
No. 10 -	Stage-Discharge Curves (1975)	$5.00
No. 11 -	Design Flood Hydrograph Estimation for Rural Catchments in Peninsular Malaysia (1975)	$5.00
No. 12 -	Magnitude and Frequency of Low Flows in Peninsular Malaysia (1975)	$5.00
No. 13 -	The Estimation of Storage-Draft Rate Characteristics for River in Peninsular Malaysia (1975)	$5.00
No. 14 -	Graphical Recorders - Instruction for Chart Changing and Annotation (1976)	$5.00
No. 15 -	River Discharge Measurement by Current Meter (1976)	$5.00

DICETAK DI JABATAN PERCETAKAN NEGARA
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KUALA LUMPUR
1980