5

RAINFALL AND RUNOFF

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The purpose of this section of this manual is to familiarize the user with available rainfall data and to document design hydrology methods currently in use in the City of Hemet and Riverside County.

The materials contained in this section are intended for the use of both City staff and engineers submitting hydrologic computations to the City. The methods presented are considered to produce hydrologic design parameters acceptable for use during the planning and design of underground storm drains, open channels, retention and detention facilities and debris basins, as well as subdivision revision and floodplain mapping.

Prior to continuing with this section, the engineer should become thoroughly familiar with the Riverside County Flood Control and Water Conservation District Hydrology Manual.

5.1 RAINFALL

The three types of storms which can occur over the Hemet-San Jacinto Valley include general winter storms, general summer storms and high intensity thunderstorms. Most precipitation results from the general winter storms which normally occur in the late fall or winter months and may have durations of several days.

General winter storms occur when warm moisture-laden Pacific air masses move inland over Southern California. Orographic lifting and cooling of the air masses results in increasing precipitation as they move eastward over the coastal plain and Santa Ana Mountains. Precipitation rates decrease over inland valleys, but as the air masses are subjected to more extensive lifting upon rising over major interior mountain ranges, such as the San Jacinto Range, high rates of precipitation again occur. As the storm continues to move eastward beyond the mountains little moisture remains, and precipitation decreases rapidly over the desert areas.

Although similar in nature to the general winter storm, general summer storms are rare and normally occur during the months of July through September. The general summer storm is the result of an influx of tropical, moisture-laden air originating over the Gulf of Mexico or the South Pacific Ocean. Although this type of storm is uncommon, it can result in large amounts of precipitation and have durations of several days.

More common than the general summer storm is the high intensity thunder storm. Although most precipitation over the City results from general winter storms, thunderstorms can occur at any time of the year causing extremely high rates of precipitation for relatively short durations. Thunderstorms can occur either during general storms, or as an isolated

phenomena, but are most common from July through September when moist unstable air subject to convective lifting may cover the Southern California area.

For design hydrology, the 3- and 6-hour duration storms are taken as representative of local thunderstorms, while the 24-hour storm is more characteristic of general storms.

5.2 INTENSITY-DURATION CURVES

Intensity-duration data is required for use with the rational method. This data is generally presented in the form of curves of rainfall intensity in inches per hour versus storm duration in minutes. Intensity-duration data for durations under three hours tend to plot in a straight line on log-log paper, and the curves for various return periods tend to run parallel to one another.

Standard intensity-duration curves have been published in master plan studies for many areas of Riverside County. In areas where these curves are still applicable they should be used in the interest of consistency. A tabular presentation of current intensity-duration data for the population centers of Hemet, San Jacinto and Idyllwild is presented on Plate 5.1. The engineer should be aware that hydrologic variations caused by terrain and other factors require caution in transposing these curves onto adjacent areas without clearly determining their applicability.

5.3 RUNOFF

The analysis of storm runoff, that is, the hydrologic aspect of urban drainage including determination of peak runoff rate, volume and time distribution of flow, is that part of the engineer's work which has the greatest effect on the success or failure of his effort. The storm runoff peak, volume and timing provide the basis for all planning, design and construction of drainage facilities.

5.3.1 Analytical Methods

Review of current practices shows that two basic approaches provide reasonable results in the Hemet-San Jacinto Valley. They are the Rational Method and the method of transposing rainfall-runoff data from gauged drainage basins to ungauged basins known as the Synthetic Unit Hydrograph.

5.3.2 Applicability of Methods

The Rational Method, in widespread use in Riverside County, will continue to be utilized for the sizing of underground storm drains and the determination of the impacts of proposed subdivisions. In addition, the Rational Method will be used when determining the runoff magnitude from areas with no developed drainage system.

5.4 RATIONAL METHOD

For basins that are not complex and have generally 500 acres or less, it is acceptable that the design storm runoff be analyzed by the Rational Method. Even though this method has frequently come under academic criticism for its simplicity, no other practical drainage design method has evolved to such a level of general acceptance by the practicing engineer.

5.4.1 Assumptions

The basic assumptions that are often made when the Rational Method is applied are:

A. The computed maximum rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.

B. The maximum rate of rainfall occurs during the time of concentration, and the design rainfall depth during the time of concentration is converted to the average rainfall intensity for the time of concentration.

C. The maximum runoff rate occurs when the entire area is contributing flow.

5.4.2 Rational Formula

The Rational Method is based on the following equation:

$$Q=CIA.$$

Q is defined as the maximum rate of runoff in cubic feet per second. Actually, Q has units of inches per acre per hour; however, the rate of inches/acre-hour differs from cubic feet per second by less than one percent and, therefore, the more common units of cubic feet per second are used.

The coefficient of runoff, C, is the ratio between the maximum rate of runoff from an area and the average rate of rainfall intensity over a duration equal to the time of concentration for the area. Values for C will be determined using Plates 5.2 through 5.5.

The intensity, I, is the average intensity of rainfall in inches per hour for a duration equal to the time of concentration. The time of concentration is typically defined as the time required for water to flow from the most remote point of the area to the point being investigated.

5.5 TIME OF CONCENTRATION

If rain were to fall continuously at a constant rate and be uniformly distributed over an impervious surface, the rate of runoff from that surface would reach a maximum rate equivalent to the rate of rainfall. This maximum would occur when all parts of the surface were contributing runoff to the concentration point. The time required to reach the maximum or equilibrium runoff rate is defined as the time of concentration.

The time of concentration is a function of many variables including the length of the flow path from the most remote point of an area to the concentration point, the slope and other characteristics of natural and improved channels in the area, the infiltration characteristics of the soil, and the degree and type of development. To avoid distortion of travel time, large subareas should be avoided. Where extremely large subareas are used, peak flow entering a travel reach may be much lower than the flow leaving that reach. Velocity normally increases with discharge; therefore, travel time computed using the average flow over a reach may be significantly lower than travel time computed using inflow to the reach. Since rainfall intensity is inversely proportional to time, flow rates would be consistently underestimated by the use of large subareas.

The following criteria shall govern the estimation of initial time of concentration and the overall length of downstream subareas.

- **The minimum time of concentration for any initial subarea shall be 10 minutes.**
- **No subarea shall have an overall length greater than 1,320 feet.**

For rational method tabling, the time of concentration for an initial subarea can be estimated using the nomograph on Plate 5.6. The time of concentration for the next downstream subarea is computed by adding to the initial time, the time required for the computed peak flow to travel to the next concentration point. Time of concentration is computed for each subsequent subarea by computing travel time between subareas and adding the cumulative sum. Travel time for natural valley and mountain channels may be estimated using Plates 5.7 through 5.8. Travel time for streets and roads may be estimated using methods developed in Section 6 of this manual.

5.7 SYNTHETIC UNIT HYDROGRAPH

Basic unit hydrograph theory for determining the rainfall-runoff relationship of a gaged basin was developed by L.K. Sherman in 1932. In 1938, F.F. Snyder developed the synthetic unit hydrograph principle making it possible to transpose rainfall-runoff data from gauged drainage basins to ungauged basins, on the basis of differences in physical basin characteristics such as shape, area, slope and so on. The methods presented herein should be used for studies on all watersheds in excess of 500 acres.

For complete discussion of the methodology and processes related to the development of unit hydrographics, the Engineer should consult the Riverside County Flood Control and Water Conservation District Hydrology Manual.

5.7.1 Development of Synthetic Unit Hydrographs

A unit hydrograph, or unit graph, for a given concentration point within a drainage area is a curve representing the time distribution of runoff occurring at the concentration point from a unit storm effective rainfall over the drainage area above the point. A unit storm is defined as a storm producing effective rainfall at a rate of one inch per

hour for a unit time duration. Effective rain is that part of the total rainfall which appears at the concentration point as surface runoff.

Basically, the synthetic unit hydrograph method transposes the characteristic time distribution of runoff from drainage areas for which runoff data areas available, to nearby areas for which data are not available. Because no two basins have the same physical characteristics, it is necessary to adjust for the differences. This is accomplished by using S-graphs appropriate for the terrain and a factor called lag.

An S-graph, or summation hydrograph, for an area is a hydrograph of runoff that would result from the continuous generation of unit storm effective rainfall over the area. For a unit storm effective rainfall rate of one inch per hour, the ultimate discharge is 645 cfs per square mile of drainage area.

Lag for a drainage area is defined as the elapsed time in hours from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration of an area reaches 50 percent of ultimate discharge. Lag time is used to relate an S-graph to a particular basin for the purpose of deriving a synthetic unit graph for that basin.

5.7.2 Development of Flood Hydrographs

A flood hydrograph for a given concentration point of a drainage area is a curve representing the time distribution of runoff that would result at that point from a design storm rainfall over the drainage area.

To develop a flood hydrograph from a unit graph, it is first necessary to determine the total effective rainfall over the drainage area and the time distribution, or pattern, of this rainfall during the storm period. The total effective rainfall to be applied to the unit hydrograph is a variable dependent upon the frequency of storm for which control is desired, the duration and pattern of the storm, and the loss rate characteristics of the drainage area.

5.8 SUBMITTAL REQUIREMENTS

Development projects undertaken within the jurisdiction of the City of Hemet will require the submittal and subsequent approval of a hydrology study prepared by, or under the direction of, a registered civil engineer.

5.9 LIST OF VARIABLES

A = Area in acres

C = Coefficient of runoff

I = Intensity in inches per hour

Q = Rate of runoff in cubic feet per second

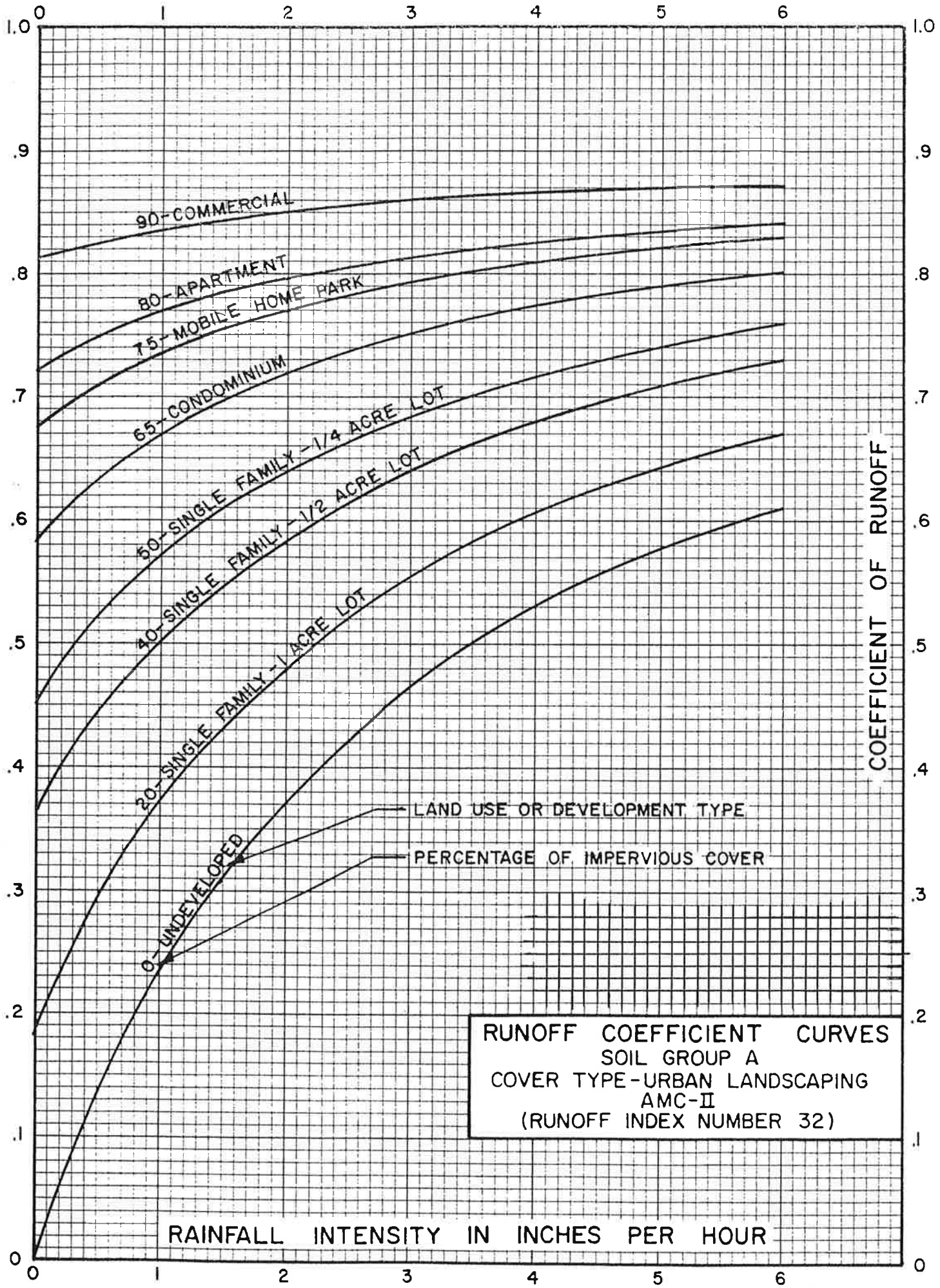
T_c = Time of concentration in minutes

5.10 REFERENCES

Riverside County Flood Control and Water Conservation District, April 1978 Hydrology Manual

Duration Minutes	Frequency	
	10 Year	100 Year
5	2.84	4.40
6	2.58	4.00
7	2.37	3.68
8	2.08	3.43
9	2.08	3.23
10	1.96	3.05
11	1.87	2.90
12	1.78	2.77
13	1.71	2.65
14	1.64	2.55
15	1.58	2.46
16	1.53	2.38
17	1.48	2.30
18	1.44	2.23
19	1.40	2.17
20	1.36	2.11
22	1.29	2.01
24	1.24	1.92
26	1.18	1.84
28	1.14	1.77
30	1.10	1.70
32	1.06	1.65
34	1.03	1.59
36	1.00	1.55
38	.97	1.50
40	.94	1.46
45	.89	1.37
50	.84	1.30
55	.80	1.24
60	.76	1.18
65	.73	1.13
70	.70	1.09
75	.68	1.05
80	.65	1.01
85	.63	.98
Slope = .530		

PLATE 5.1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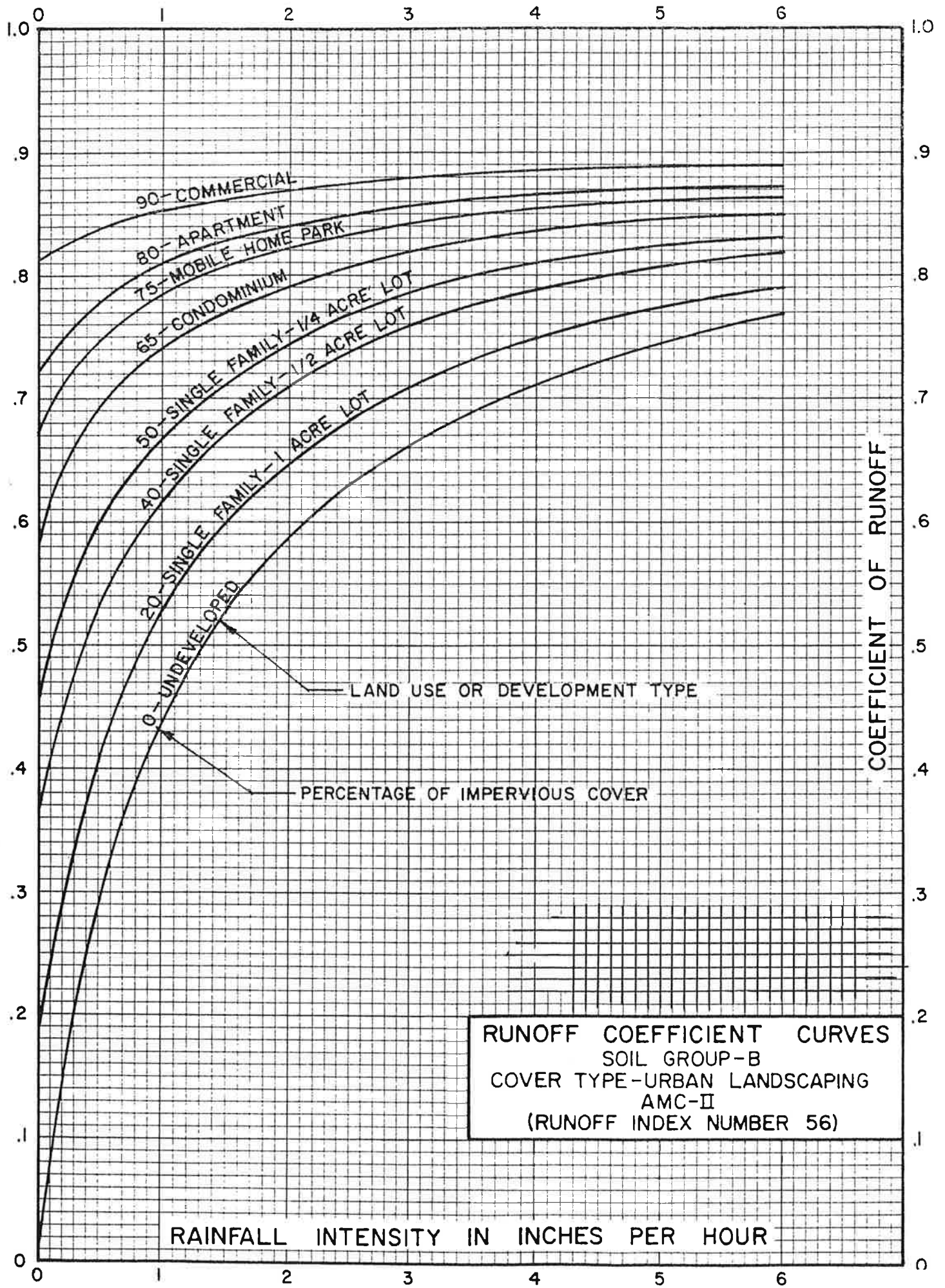
90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
COEFFICIENT OF RUNOFF
RUNOFF COEFFICIENT CURVES
SOIL GROUP A
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 32)
RAINFALL INTENSITY IN INCHES PER HOUR

PLATE 5.2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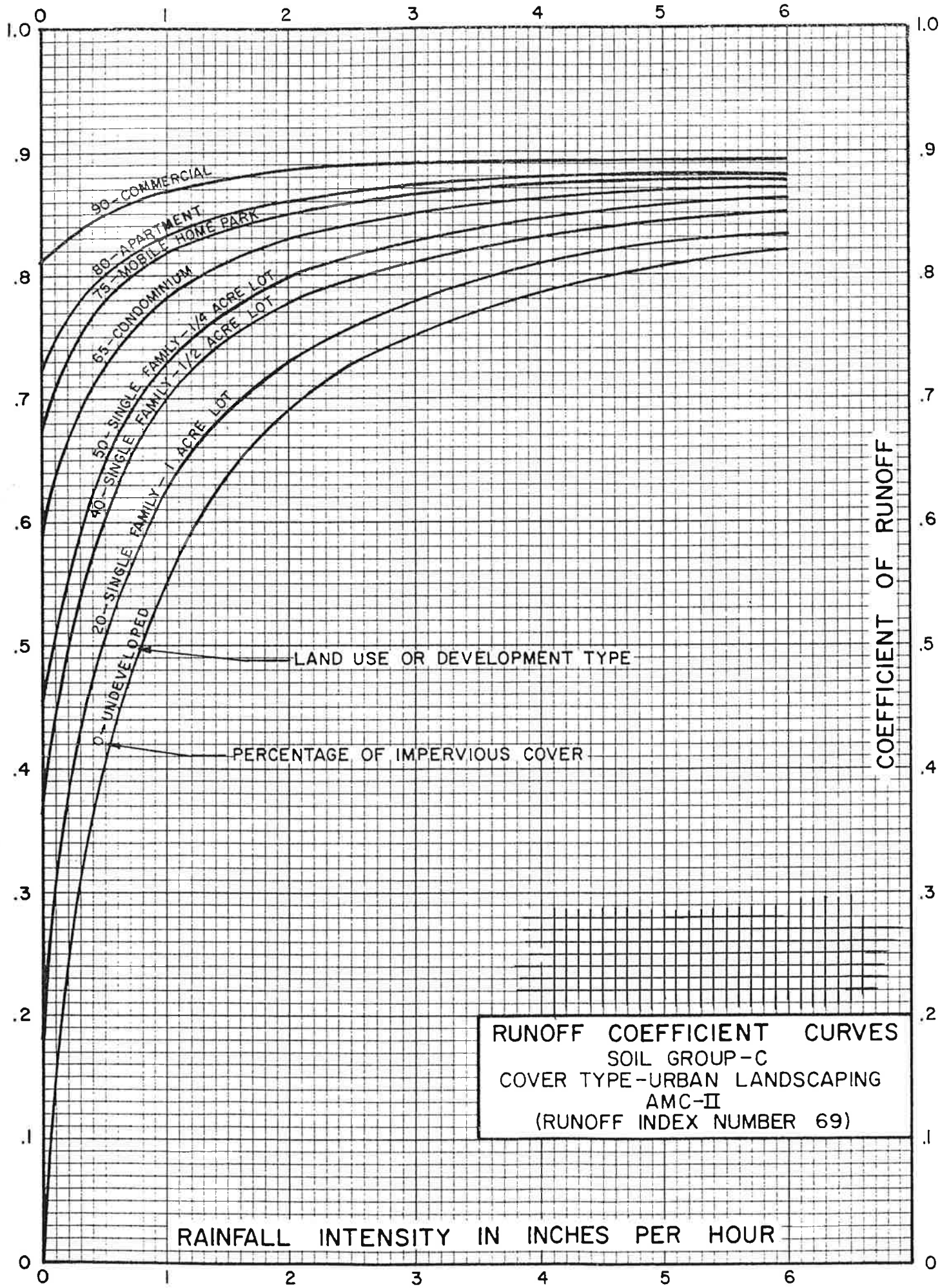
90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
COEFFICIENT OF RUNOFF
RUNOFF COEFFICIENT CURVES
SOIL GROUP-B
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 56)
RAINFALL INTENSITY IN INCHES PER HOUR

PLATE 5.3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90 - COMMERCIAL
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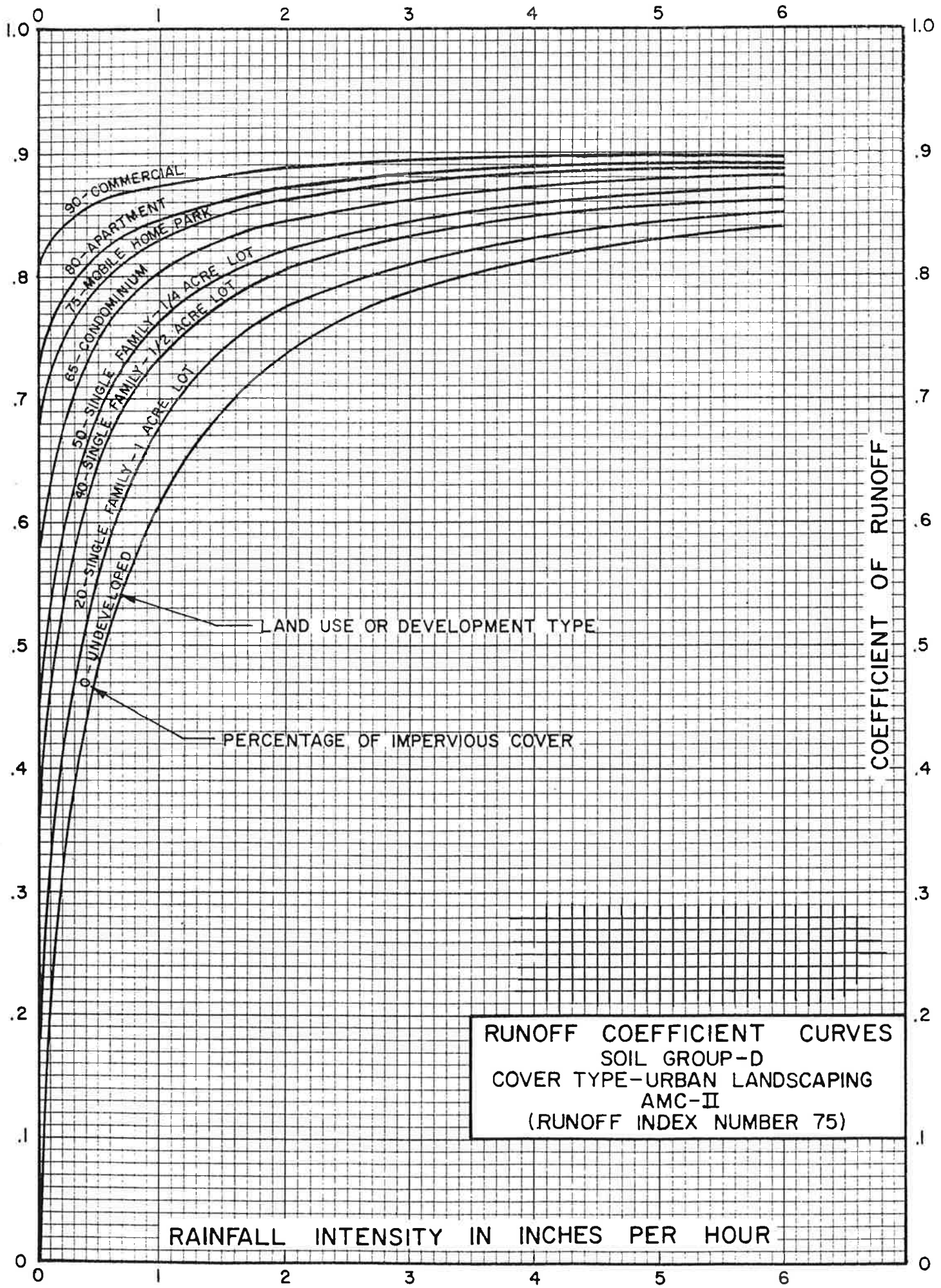
75 - MOBILE HOME PARK
65 - CONDOMINIUM
50 - SINGLE FAMILY - 1/4 ACRE LOT
40 - SINGLE FAMILY - 1/2 ACRE LOT
20 - SINGLE FAMILY - 1 ACRE LOT
0 - UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
COEFFICIENT OF RUNOFF
RUNOFF COEFFICIENT CURVES
SOIL GROUP - C
COVER TYPE - URBAN LANDSCAPING
AMC - II
(RUNOFF INDEX NUMBER 69)
RAINFALL INTENSITY IN INCHES PER HOUR

PLATE 5.4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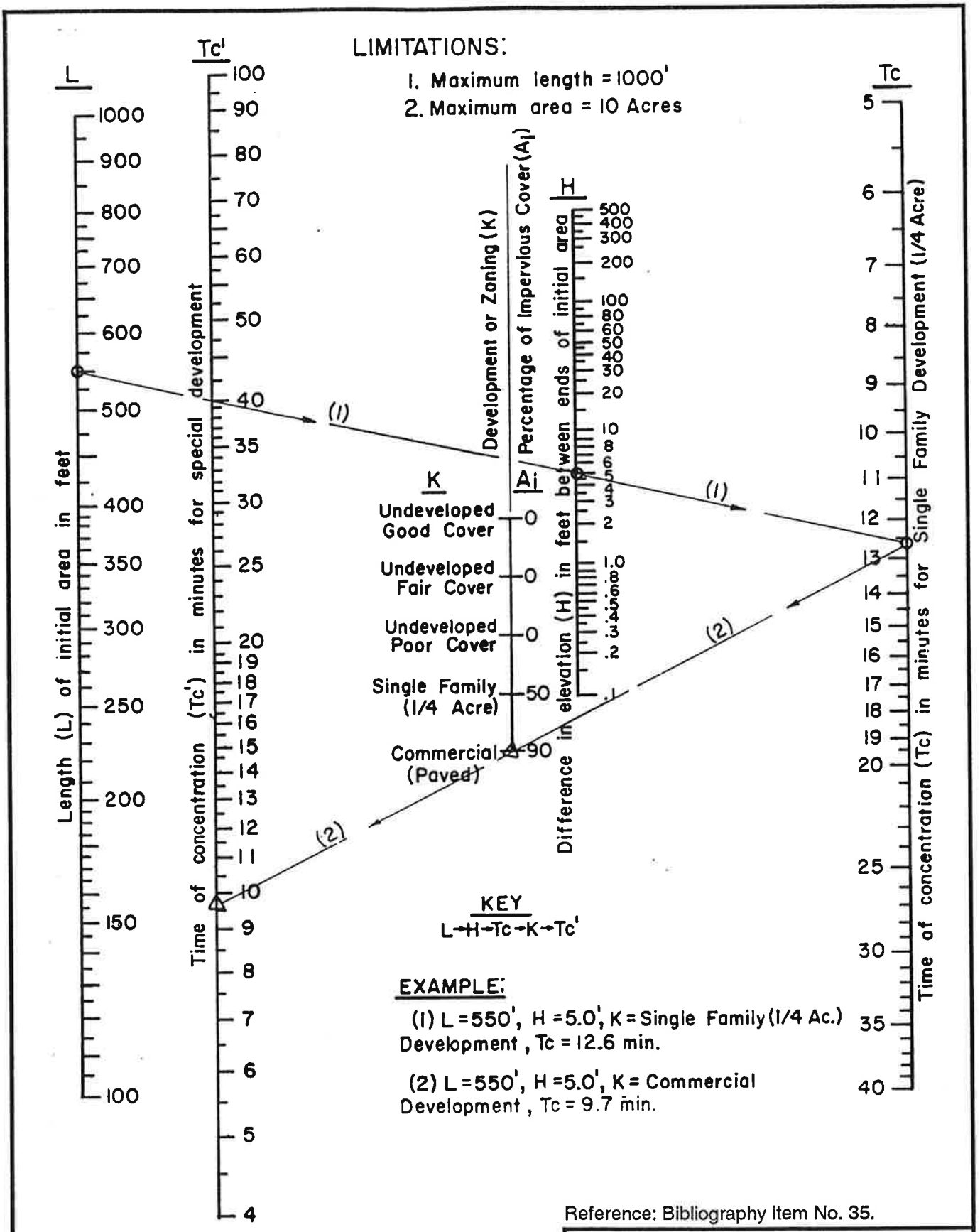
90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
COEFFICIENT OF RUNOFF
RUNOFF COEFFICIENT CURVES
SOIL GROUP-D
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 75)
RAINFALL INTENSITY IN INCHES PER HOUR

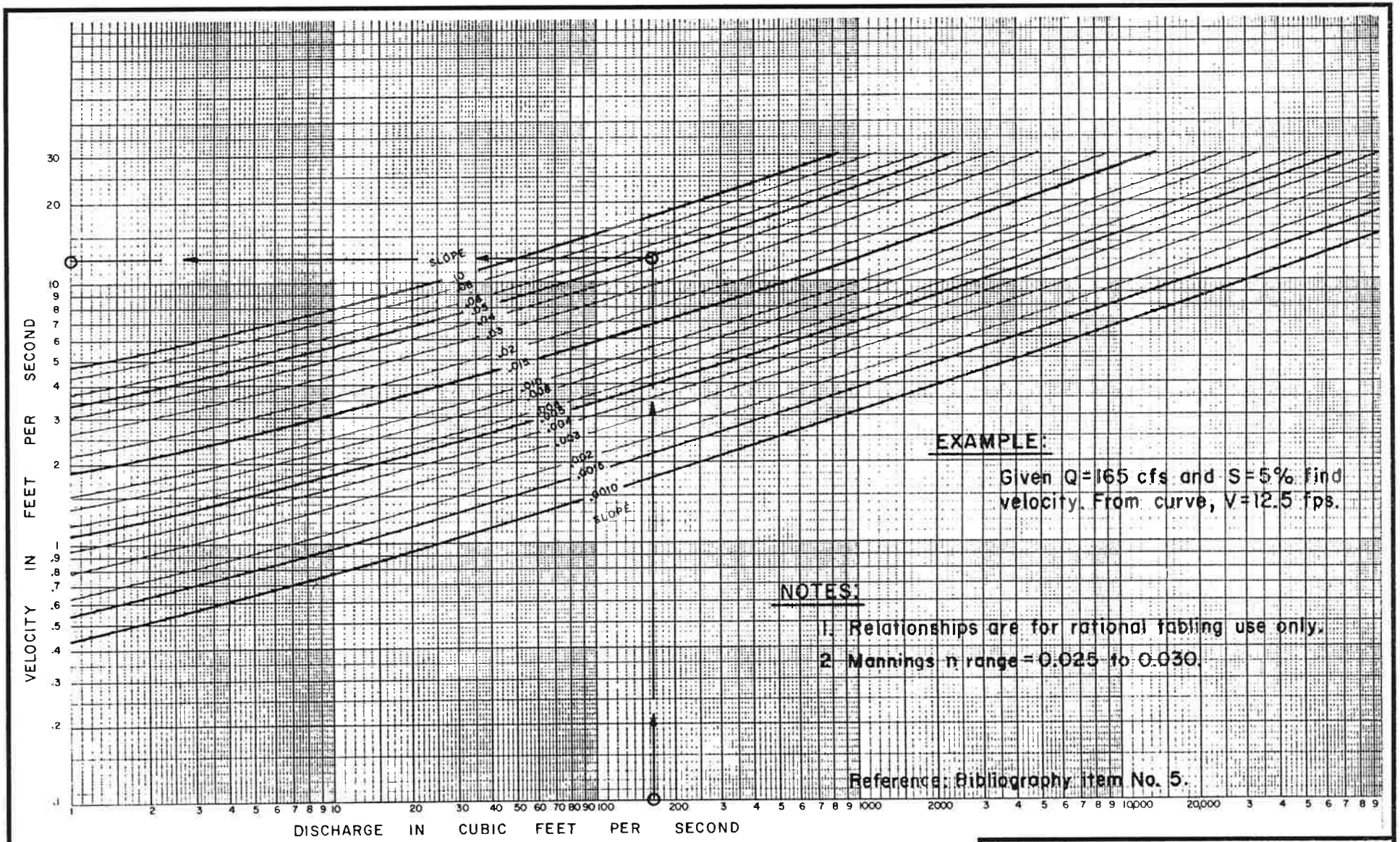
PLATE 5.5



Reference: Bibliography item No. 35.

CITY OF HEMET
STORM DRAIN DEVELOPMENT STANDARDS,
STORM DRAIN CRITERIA AND
DRAINAGE DESIGN MANUAL

TIME OF CONCENTRATION FOR INITIAL SUB AREA

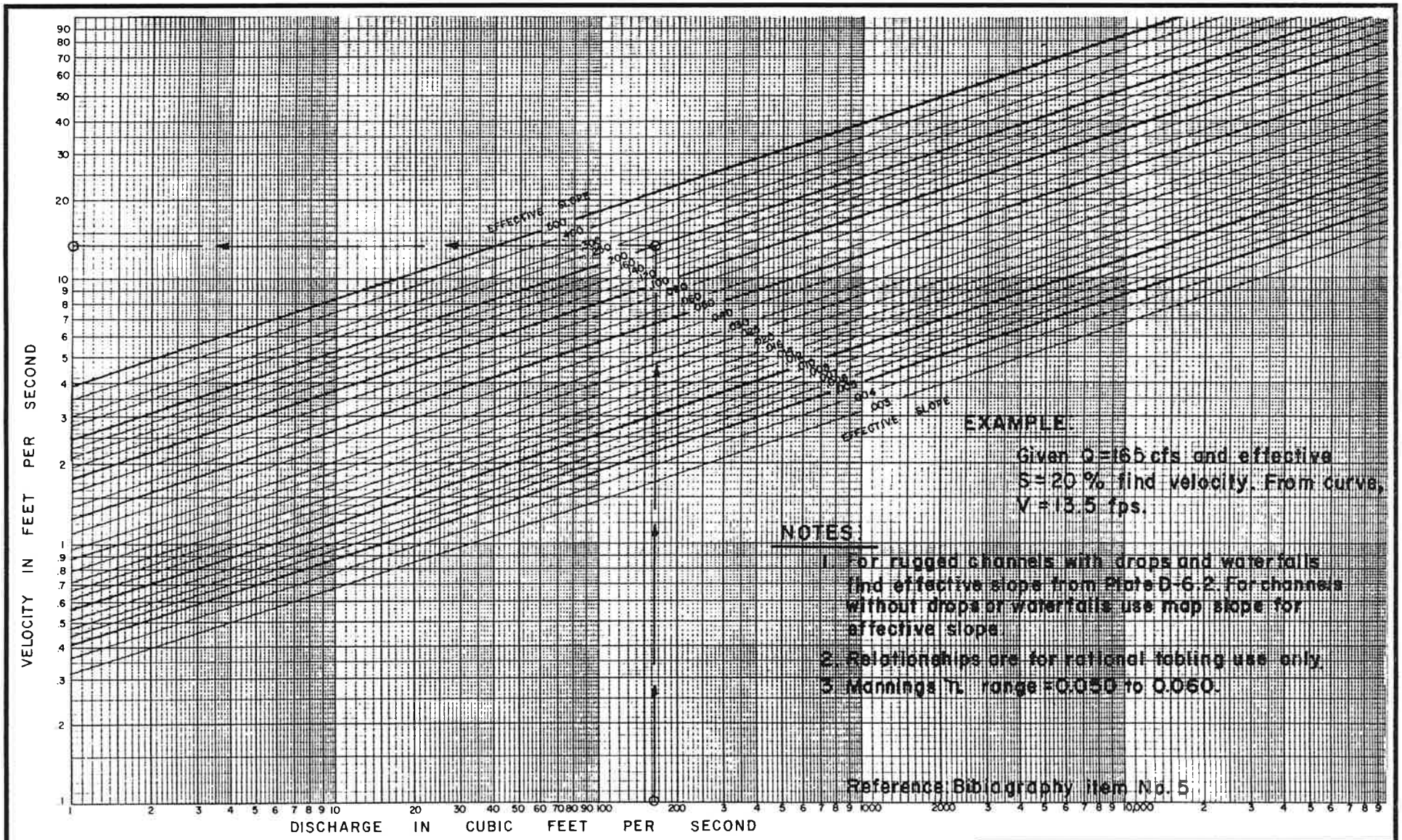


CITY OF HEMET
STORM DRAIN DEVELOPMENT STANDARDS,
STORM DRAIN CRITERIA AND
DRAINAGE DESIGN MANUAL

VELOCITY - DISCHARGE - SLOPE RELATIONSHIPS

NATURAL VALLEY CHANNELS

PLATE 5.7



CITY OF HEMET
STORM DRAIN DEVELOPMENT STANDARDS,
STORM DRAIN CRITERIA AND
DRAINAGE DESIGN MANUAL

VELOCITY - DISCHARGE - SLOPE RELATIONSHIPS

NATURAL VALLEY CHANNELS

PLATE 5.8