6.13 USGS Regression Equations – Adjustment for Basin Urbanization

6.13.1 Introduction

The United States Geological Survey has developed three sets of regression equations to estimate flood discharges for ungaged urban sites for various recurrence intervals. Two sets of equations are based on seven independent parameters and the third is based upon three independent parameters. The three parameter estimating equations, listed in Table 6.6, are recommended for use where applicable in the evaluation of urban peak discharges for ungaged sites with drainage areas between 1 and 100 square miles. For complete information regarding background data and research related to the development of these equations, the reader is referred to the publication entitled "Flood Characteristics of Urban Watersheds in the United States, U.S. Geological Survey Paper 2207," dated 1983.

The Basin Development Factor (BDF) has been identified by the USGS as the most important indicator of urbanization for use in the estimating equations. This factor, which provides a measure of the efficiency of the drainage systems within an urbanizing watershed, is determined as explained below. (See FHWA publication entitled "Highway Hydrology," HDS-2, Second Edition, October 2002.)

6.13.2 Characteristics

The basin is first divided into three sections as shown in Figure 6.7. Each section contains approximately a third of the drainage area of the watershed. Travel time is given consideration when drawing these boundaries so that the travel distances along two or more streams within a particular third are about equal. This does not mean that the travel distances of all three subareas are equal; only that within a particular subarea the travel distances are approximately equal.

Within each section of the basin, four aspects of the drainage system are evaluated and assigned a code, as follows:

1) Channel Improvements - If channel improvements such as straightening, enlarging, deepening and/or clearing are prevalent for the main drainage channel and principal tributaries (those that drain directly into the main channel), then a code of one (1) is assigned. Any one, or all of these improvements would qualify for a code of one (1). To be considered prevalent, at least 50 percent of the main drainage channel and principal tributaries must be improved to some extent over natural conditions. If channel improvements are not prevalent, a code of zero (0) should be assigned.
2) Channel Linings - If more than 50 percent of the main drainage channel and principal tributaries have been lined with an impervious material, such as concrete, then a code of one (1) is assigned. If less than 50 percent of these channels are lined, then a code of zero (0) is assigned. The presence of channel linings would probably indicate the presence of channel improvements as well. Therefore, this is an added factor and indicates a more highly developed drainage system.
3) Storm Drains - Storm drains are defined as enclosed drainage structures (usually pipes), frequently used on the secondary tributaries where the drainage is received directly from streets or parking lots. Quite often these drains empty into the main tributaries and channel which are either open channels, or in some basins may be enclosed as pipes or box culverts. When more than 50 percent of the secondary tributaries within a section consists of storm drains, then a code of one (1) is assigned. If less than 50 percent of the secondary tributaries

consist of storm drains, then a code of zero (0) is assigned. It should be noted that if more than 50 percent of the main drainage channels and principal tributaries are enclosed, then the aspects of channel improvements and channel linings would also be assigned a code of one (1).

4) Curb and Gutter Streets - If more than 50 percent of a subarea is urbanized (covered by residential, commercial and/or industrial development), and if more than 50 percent of the streets and highways in the subarea are constructed with curbs and gutters, then a code of one (1) should be assigned. Otherwise, a code of zero (0) is assigned. Frequently, drainage from curb and gutter streets will empty into storm drains.

The above guidelines for determining the various drainage system codes are not intended to be precise measurements. A certain amount of subjectivity is involved. It is recommended that field checking be performed to obtain the best estimate. The basin development factor (BDF) is computed as the sum of the assigned codes (SEE BDF calculation sheet Table 6-7). With three subareas per basin, and four drainage aspects to which codes are assigned in each subarea, the maximum value for a fully developed drainage system would be 12.

Conversely, if the drainage system has not been developed, then a BDF of zero (0) would result.

The BDF is a simple index to estimate for an existing urban basin. The 50 percent guideline is usually not difficult to evaluate because many urban areas tend to use the same design criteria throughout, and therefore the drainage aspects are similar throughout. Also, the BDF is convenient to use for projecting future development. Projections of full development, or intermediate stages of development, can usually be obtained from city engineers.

Equations

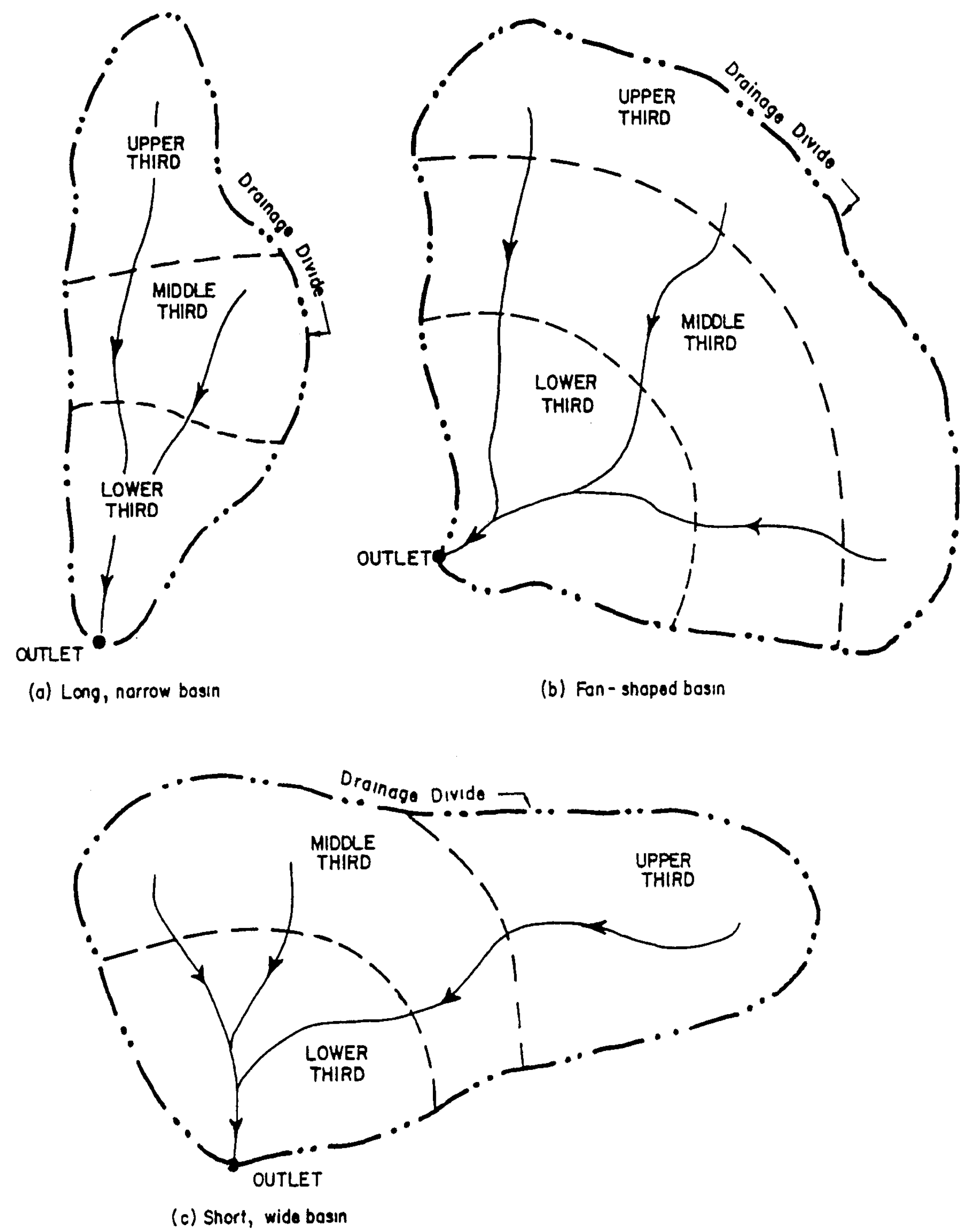
USGS Three Parameter Estimating Equations

Equation	Standard error %	
$UQ_2 = 13.2A^{0.21}(13 - BDF)^{-0.43} RQ_2^{0.73}$	+/- 43	**(6.18)**
$UQ_{10} = 9.51A^{0.16}(13 - BDF)^{-0.36} RQ_{10}^{0.79}$	+/- 41	**(6.19)**
$UQ_{25} = 8.68A^{0.15}(13 - BDF)^{-0.34} RQ_{25}^{0.80}$	+/- 43	**(6.20)**
$UQ_{50} = 8.04A^{0.15}(13 - BDF)^{-0.32} RQ_{50}^{0.81}$	+/- 44	**(6.21)**
$UQ_{100} = 7.70A^{0.15}(13 - BDF)^{-0.32} RQ_{100}^{0.82}$	+/- 46	**(6.22)**
$UQ_{500} = 7.47A^{0.16}(13 - BDF)^{-0.30} RQ_{500}^{0.82}$	+/- 52	**(6.23)**

Where:

UQr = the peak discharge of recurrence interval, r, for an urbanized condition in cfs
A = the drainage area in square miles
BDF = the Basin Development Factor
RQr = the peak discharge of recurrence interval, r, for rural conditions

Table 6-6



Schematic of typical drainage basin shapes and subdivision into basin thirds. Note that stream-channel distances within any given third of a basin in the examples are approximately equal, but between basin thirds the distances are not equal, to compensate for relative basin width of the thirds.

Figure 6-7 Subdivision of Watersheds for Determination of Basin Development Factor

Table 6-7 BASIN DEVELOPMENT FACTOR CALCULATION SHEET

Basin Characteristic	Upper Third	Middle Third	Lower Third
Channel Improvements			
Channel Linings			
Storm Drains or Storm Sewers			
Curb and Gutter Streets			
Sub Totals			

____________ + _______________ + ___________ = BDF