

CHAPTER 4

RUNOFF

RAINFALL

4.1 INTRODUCTION

Presented in this section is the design rainfall data to be used with the Colorado Urban Hydrograph Procedure (CUHP) and the Rational Method.

The rainfall data published by the National Oceanic and Atmospheric Administration (NOAA) in the "Precipitation-Frequency Atlas of the Western United States, Volume III - Colorado" was used to develop one hour and six hour point rainfall values. These point values were then used to develop two hour and three hour design rainfall distributions as well as time-intensity-frequency curves. The design storms were defined using the procedures developed by the UD&FCD. The calculations for the design storms have been published in a technical memorandum (Reference 27) on file with Adams County and the UD&FCD.

4.2 CUHP DESIGN STORMS

4.2.1 Basis of Design Storm Distribution

Rainfall in the Adams County area is influenced by the orographic effects of the Rocky Mountains, the topography of the high plains and the semi-arid climatology of the region. Rainstorms can often have an "upslope" character where easterly flow of moisture settles against the mountains. These types of rainstorms have durations that can exceed six hours and produce large amount of total precipitation. However, these storms are rarely intense and seldom result in urban flooding problems.

Very intense rainfall in the Adams County area results from convection storms or frontal stimulated convective storms. These types of storms are often less than one hour or two hours in duration and can produce brief periods of high rainfall intensities. these short duration intense rainstorms appear to cause most of the urban flooding problems.

Analysis of a 73-year record of rainfall at the Denver raingauge by the UD&FCD reveals that an overwhelming majority of the intense rainstorms produce their greatest intensities in the first hour of the storm. In fact, of the 73 most intense storms analyzed, 68 had the most intense period beginning and ending within the first hour of the storm and 52 had the most intense period beginning and ending within the first half hour of the storm. The data clearly shows that the leading intensity storms predominate among the "non-upslope" type storms in the Denver Region.

The recommended design storm distribution takes into account the observed "leading intensity" nature of the convection storms. In addition, the temporal distributions were designed to be used with the 1982 version of the CUHP, the published NOAA one hour precipitation values, and the Horton's infiltration loss equation. They were developed to approximate the recurrence frequency of peak flows and volumes (i.e., 2 through 100 years) that were estimated for the watershed for which rainfall/runoff data was collected. The procedure for the design storm distributions and the preliminary results were reported at the 1979 International Symposium on Urban Storm Runoff. The recommendations contained herein are the results of refinements to the work by the UD&FCD.

4.2.2

Basins Less than Five Square Miles

For drainage basins less than five square miles, a two-hour storm distribution without area adjustment of the point rainfall values shall be used for CUHP. The incremental rainfall distribution is presented in Table 401.

4.2.3

Basins Between Five and Ten Square Miles

For drainage basins between five and ten square miles, a two-hour storm distribution is used but the incremental rainfall values are adjusted for the large basin area in accordance with suggested procedures in the NOAA Atlas for Colorado. The adjustment is an attempt to relate the average of all point values for a given duration and frequency within a basin to the average depth over the basin for the same duration and frequency. The incremental rainfall distribution is presented in Table 401.

4.2.4 Basins Between Ten and Twenty Square Miles

For drainage basins between ten and twenty square miles, a three-hour storm duration with adjustment for area shall be used. The distribution for the last hour was obtained by uniformly distributing the difference between the two and three hour point rainfall values. The adjustment for area was obtained from the NOAA Atlas for Colorado. The incremental rainfall distribution is presented in Table 401.

4.3 TIME-INTENSITY-FREQUENCY CURVES

The one-hour design point rainfall values obtained from the NOAA Atlas for Colorado are as follows:

ONE HOUR POINT RAINFALL (INCHES)

<u>2 YEAR</u>	<u>5 YEAR</u>	<u>10 YEAR</u>	<u>50 YEAR</u>	<u>100 YEAR</u>
1.00	1.42	1.62	2.35	2.71

The Time-Intensity-Frequency curves were developed by distributing the one-hour point rainfall values using the factors obtained from the NOAA Atlas presented below:

FACTORS FOR DURATIONS OF LESS THAN ONE HOUR

Duration (minutes)	5	10	15	30
Ratio to 1-hour depth	0.29	0.45	0.57	0.79

Source: NOAA Atlas 2, Volume III, Colorado 1973

The point values were then converted to intensities and plotted on Figure 401. The data are also presented in Table 402.

STORM DRAINAGE DESIGN

TABLE 401

DESIGN STORMS FOR ADAMS COUNTY

INCREMENTAL RAINFALL DEPTH/RETURN PERIOD

TIME (Min)	BASINS LESS THAN 5 SQ. MILES					BASINS BETWEEN 5 AND 10 SQ. MILES					BASINS BETWEEN 10 AND 20 SQ MILES				
	2-YR (IN)	5-YR (IN)	10-YR (IN)	50-YR (IN)	100-YR (IN)	2-YR (IN)	5-YR (IN)	10-YR (IN)	50-YR (IN)	100-YR (IN)	2-YR (IN)	5-YR (IN)	10-YR (IN)	50-YR (IN)	100-YR (IN)
5	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
10	0.04	0.05	0.06	0.08	0.08	0.04	0.05	0.06	0.08	0.08	0.04	0.05	0.06	0.08	0.08
15	0.08	0.12	0.14	0.12	0.12	0.08	0.12	0.14	0.12	0.12	0.08	0.12	0.14	0.12	0.12
20	0.16	0.22	0.25	0.19	0.22	0.15	0.21	0.25	0.19	0.22	0.14	0.20	0.25	0.19	0.22
25	0.25	0.36	0.42	0.35	0.38	0.24	0.35	0.40	0.34	0.36	0.23	0.32	0.38	0.32	0.34
30	0.14	0.18	0.20	0.59	0.68	0.13	0.17	0.19	0.57	0.65	0.13	0.16	0.18	0.53	0.61
35	0.06	0.08	0.09	0.28	0.38	0.06	0.08	0.09	0.27	0.36	0.06	0.08	0.09	0.25	0.34
40	0.05	0.06	0.07	0.19	0.22	0.05	0.06	0.07	0.19	0.22	0.05	0.06	0.07	0.19	0.22
45	0.03	0.05	0.06	0.12	0.17	0.03	0.05	0.06	0.12	0.17	0.03	0.05	0.06	0.12	0.17
50	0.03	0.05	0.05	0.12	0.14	0.03	0.05	0.05	0.12	0.14	0.03	0.05	0.05	0.12	0.14
55	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11
60	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11
65	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11	0.03	0.04	0.05	0.08	0.11
70	0.02	0.04	0.05	0.06	0.05	0.02	0.04	0.05	0.06	0.05	0.02	0.04	0.05	0.06	0.05
75	0.02	0.03	0.05	0.06	0.05	0.02	0.03	0.05	0.06	0.05	0.02	0.03	0.05	0.06	0.05
80	0.02	0.03	0.04	0.04	0.03	0.02	0.03	0.04	0.04	0.03	0.02	0.03	0.04	0.04	0.03
85	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.03
90	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
95	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
100	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
105	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
110	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
115	0.01	0.02	0.03	0.03	0.03	0.01	0.02	0.03	0.03	0.03	0.01	0.02	0.03	0.03	0.03
120	0.01	0.02	0.02	0.03	0.03	0.01	0.02	0.02	0.03	0.03	0.01	0.02	0.02	0.03	0.03
125											0.01	0.02	0.02	0.02	0.02
130											0.01	0.01	0.02	0.02	0.02
135											0.01	0.02	0.01	0.02	0.02
140											0.01	0.02	0.01	0.02	0.02
145											0.01	0.01	0.01	0.02	0.02
150											0.01	0.01	0.01	0.01	0.02
155											0.01	0.01	0.01	0.01	0.01
160											0.01	0.01	0.01	0.01	0.01
165											0.01	0.01	0.01	0.01	0.01
170											0.01	0.01	0.01	0.01	0.01
175											0.01	0.01	0.01	0.01	0.01
180											0.01	0.01	0.01	0.00	0.00

TOTAL:	1.15	1.61	1.89	2.72	3.12	1.12	1.58	1.86	2.68	3.05	1.22	1.68	1.97	2.76	3.14
--------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

DATE:
REV:

REFERENCE:

WRC Engineering, Inc. TM-1, February 1989

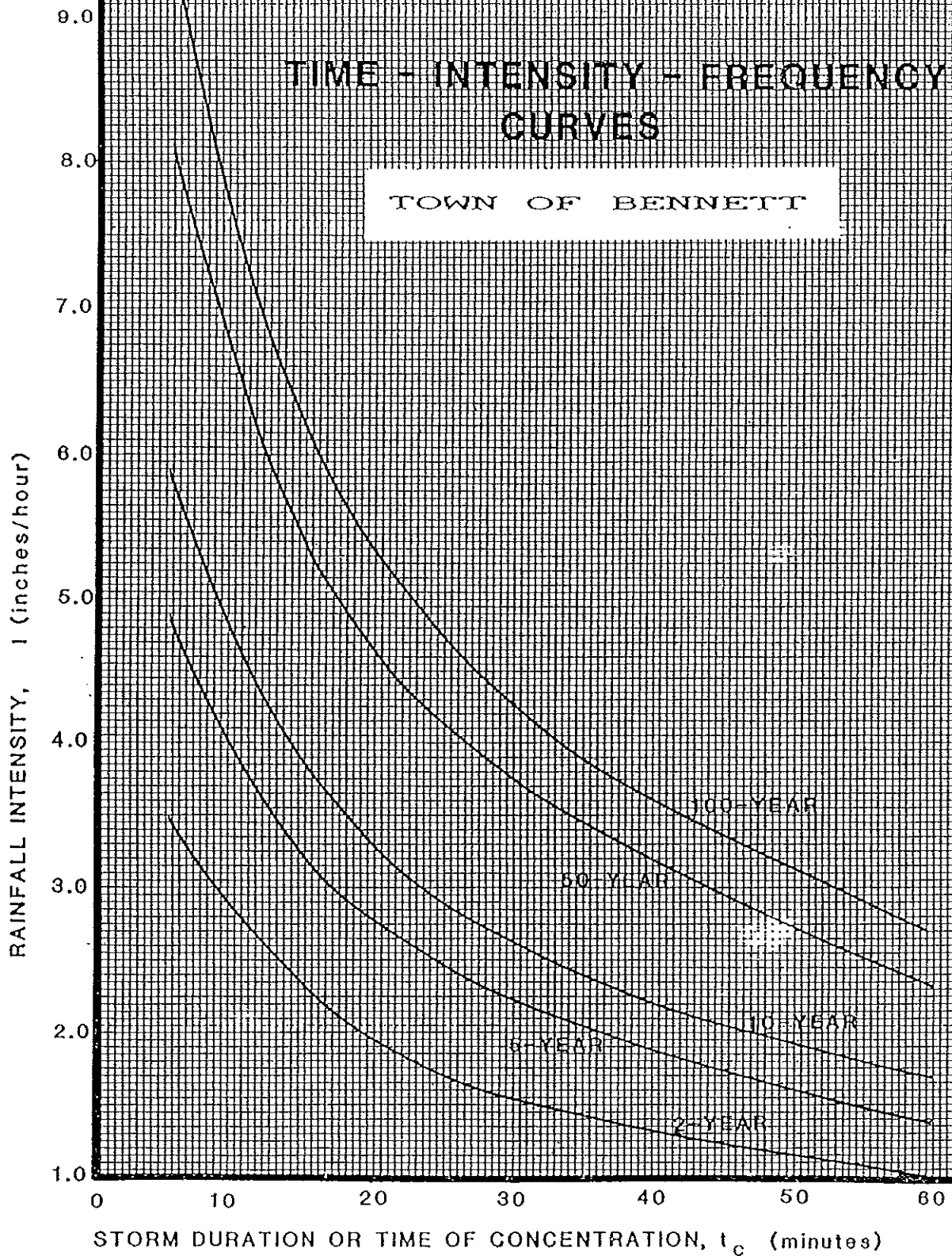
TIME - INTENSITY - FREQUENCY TABULATION

DURATION FACTORS FREQ.	5 MIN 0.29		10 MIN 0.45		15 MIN 0.57		30 MIN .79		60 MIN 1.00	
	DEPTH (IN)	INTEN. (IN/HR)	DEPTH (IN)	INTEN. (IN/HR)	DEPTH (IN)	INTEN. (IN/HR)	DEPTH (IN)	INTEN. (IN/HR)	DEPTH (IN)	INTEN. (IN/HR)
2-YR	0.29	3.48	0.45	2.70	0.57	2.28	0.79	1.58	1.00	1.00
5-YR	0.41	4.92	0.64	3.84	0.81	3.24	1.12	2.24	1.42	1.42
10-YR	0.49	5.88	0.76	4.56	0.96	3.84	1.33	2.66	1.68	1.68
50-YR	0.68	8.16	1.06	6.36	1.34	5.36	1.86	3.72	2.35	2.35
100-YR	0.79	9.48	1.22	7.32	1.54	6.16	2.14	4.28	2.71	2.71

NOTE: Depth at each duration = one hour rainfall depth x respective duration factor

Date:
Rev:

REFERENCE: WRC Engineering, Inc. TM-1, February 1989



Date:
Rev:

REFERENCE: