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## **SECTION 3.0 RAINFALL**

### **3.1 INTRODUCTION**

Presented in this section is the design rainfall data to be used with the Colorado Urban Hydrograph Procedure (CUHP) and the Rational Method. All hydrological analysis within the jurisdiction of these Criteria shall use the rainfall data presented herein for calculating storm runoff.

The design storms and intensity-duration-frequency curves for the City were developed using the rainfall data as presented in the NOAA Atlas for Colorado and the procedures presented in the Urban Storm Drainage Criteria Manual (USDCM).

### **3.2 SELECTION OF DESIGN STORM FREQUENCIES**

All drainage systems for new development have to take into consideration two separate and distinct drainage situations. The first is the initial storm, which occurs at regular intervals and is based on the two, five and ten year storm events, depending on land use. The runoff from the initial storm is usually not the cause of extensive damage, but can represent higher costs in maintenance, repair and replacement of public facilities if not handled correctly.

The second drainage situation that shall be considered is the planning and design of facilities to convey the major storm, which occurs at less frequent intervals, and is based on the 100-year storm event. The runoff from this type of storm event can cause catastrophic property damage and personal injury or loss of life.

The purpose of the major drainage path criteria is to establish guidelines to protect the major paths from encroachment. No development shall be allowed along the major drainage path except by specific approval of the City. The major drainage paths are shown on exhibits in the Comprehensive Drainage Plans for each major drainage basin within the City. All development that occurs along the major paths will be required to meet the guidelines herein. The guidelines herein are intended to be supplements to the specific recommendations made for each drainage basin analyzed in the Comprehensive Drainage Plans.

The major drainage paths are a part of the major drainage system and all facilities along said paths will be required to be designed using a 100-year design storm frequency. The only exceptions are those specific design storm frequencies recommended for the drainage basin investigated by the Comprehensive Drainage Plans.

The 100-year runoff shall be computed at the point where the major drainage path enters the proposed development and again where the major drainage path leaves the development. Intermediate points of runoff shall be computed where deemed critical and to better define the major drainage path. Critical points are generally identified by the intersection of a drainage path with the major drainage path, rapid changes in grades or channel widths. The runoff shall be based on the total area tributary to the runoff point regardless of the ratio of developed area to the drainage basin.

The width of the channel and maintenance access to the channel shall be as defined in Section 5.0-Open Channels. No development will be allowed within this designated area. Said area shall be called a drainage easement and identified as such on all plans and plats. Drainage easements shall be dedicated to the City for public use. Access roads shall be dedicated to the City where necessary.

Where possible and as required by the City, the major drainage channels shall be incorporated into greenbelt and recreational areas. Natural drainage channels lend themselves to greenbelt areas. Where the width can be extended, hiking trails, pedestrian walkways and bicycle paths

should be located in the major drainage path. Due consideration should be given to street and utility layout to gain maximum aesthetic use of the drainage path.

The initial and major storm frequencies used for runoff analysis and the subsequent design of stormwater control facilities in the City of Greeley are presented below:

<b>TABLE 3.2 - DESIGN STORM FREQUENCIES</b>		
<b>Land Use</b>	<b>Initial Storm Frequency</b>	<b>Major Storm Frequency</b>
Residential	2-year	100-year
Commercial, Business & Industrial	5-year	100-year
Downtown Business Area, Airport Terminals and Industrial (1)	10-year	100-year

(1) Any industrial development within or adjacent to airport terminals or the downtown business area shall have an initial storm frequency of 10-years.

### **3.3 COLORADO URBAN HYDROGRAPH PROCEDURE (CUHP) DESIGN STORMS**

For drainage basins less than five square miles, a two-hour storm distribution without area adjustments of the point rainfall values shall be used for CUHP. 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.

For drainage basins between ten and twenty square miles, a three-hour storm distribution 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 for all basin areas up to 20 square miles is presented in Table 3-1.

### **3.4 INTENSITY-DURATION-FREQUENCY (IDF) CURVES**

Intensity-Duration-Frequency (IDF) curves are necessary to utilize the Rational Method for runoff analysis. The one-hour design point rainfall values obtained from the NOAA Atlas for Colorado are required for the development of the IDF curves. The one-hour point rainfall values applicable for the City of Greeley are presented below.

<b>TABLE 3.4 - ONE-HOUR POINT RAINFALL (INCHES)</b>				
<b>2-year</b>	<b>5-year</b>	<b>10-year</b>	<b>50-year</b>	<b>100-year</b>
1.04	1.49	1.76	2.51	2.78

The IDF curves were developed by distributing the one-hour point rainfall values using the factors obtained from the NOAA Atlas as presented below.

<b>TABLE 3.4(1) - FACTORS FOR DURATIONS OF LESS THAN ONE HOUR</b>				
<b>Duration (minutes)</b>	<b>5</b>	<b>10</b>	<b>15</b>	<b>30</b>
<b>Ratio to 1-hour Depth</b>	0.29	0.45	0.57	0.79

The point values were then converted to intensities and plotted on Figure 3-1. The data are also presented in Tables 3-1, 3-2, and 3-3.

## DESIGN STORMS FOR GREELEY

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	0.04	0.03	0.03	0.02	0.03	0.04	0.03	0.03	0.02	0.03	0.04	0.03	0.03
10	0.04	0.06	0.07	0.09	0.08	0.04	0.06	0.07	0.09	0.08	0.04	0.06	0.07	0.09	0.08
15	0.09	0.13	0.14	0.13	0.13	0.09	0.13	0.14	0.13	0.13	0.09	0.13	0.14	0.13	0.13
20	0.17	0.23	0.26	0.20	0.22	0.16	0.22	0.25	0.20	0.22	0.15	0.21	0.24	0.20	0.22
25	0.26	0.37	0.44	0.38	0.39	0.25	0.36	0.42	0.36	0.37	0.23	0.34	0.40	0.34	0.35
30	0.15	0.19	0.21	0.63	0.70	0.14	0.19	0.20	0.60	0.67	0.13	0.17	0.19	0.57	0.63
35	0.07	0.09	0.10	0.30	0.39	0.07	0.09	0.01	0.29	0.37	0.07	0.09	0.10	0.27	0.35
40	0.05	0.07	0.08	0.20	0.22	0.05	0.07	0.08	0.20	0.22	0.05	0.07	0.08	0.20	0.22
45	0.03	0.05	0.07	0.13	0.17	0.03	0.05	0.07	0.13	0.17	0.03	0.05	0.07	0.13	0.17
50	0.03	0.05	0.06	0.08	0.14	0.03	0.05	0.06	0.08	0.14	0.03	0.05	0.06	0.08	0.14
55	0.03	0.05	0.06	0.08	0.11	0.03	0.05	0.06	0.08	0.11	0.03	0.05	0.06	0.08	0.11
60	0.03	0.05	0.06	0.08	0.11	0.03	0.05	0.06	0.08	0.11	0.03	0.05	0.06	0.08	0.11
65	0.03	0.05	0.06	0.06	0.11	0.03	0.05	0.06	0.06	0.11	0.03	0.05	0.06	0.06	0.11
70	0.02	0.05	0.06	0.06	0.06	0.02	0.05	0.06	0.06	0.06	0.02	0.05	0.06	0.06	0.06
75	0.02	0.04	0.06	0.05	0.06	0.02	0.04	0.06	0.05	0.06	0.02	0.04	0.06	0.05	0.06
80	0.02	0.03	0.04	0.05	0.03	0.02	0.03	0.04	0.05	0.03	0.02	0.03	0.04	0.05	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	0.04	0.03	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.03
95	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
100	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03
105	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03
110	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.03
115	0.01	0.02	0.03	0.04	0.03	0.01	0.02	0.03	0.04	0.03	0.01	0.02	0.03	0.04	0.03
120	0.01	0.02	0.02	0.04	0.03	0.01	0.02	0.02	0.04	0.03	0.01	0.02	0.02	0.04	0.03
125											0.01	0.01	0.02	0.02	0.02
130											0.01	0.01	0.01	0.02	0.02
135											0.01	0.01	0.01	0.01	0.02
140											0.01	0.01	0.01	0.01	0.01
145											0.01	0.01	0.01	0.01	0.01
150											0.01	0.01	0.01	0.01	0.01
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											0.00	0.00	0.01	0.00	0.01
175											0.00	0.00	0.00	0.00	0.01
180											0.00	0.00	0.00	0.00	0.01
<b>TOTAL</b>	1.20	1.72	2.04	2.81	3.21	1.18	1.69	2.00	2.76	3.15	1.24	1.73	2.05	2.79	3.22

Reference: Miller, J.F., and Tracey, R.J.

Precipitation-Frequency Analysis of the Western United States  
(NOAA Atlas) Volume III - Colorado 1973



# STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

TABLE 3-1

PUBLIC WORKS DEPARTMENT  
STORMWATER MANAGEMENT DIVISION  
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS  
REVISED MARCH 2007

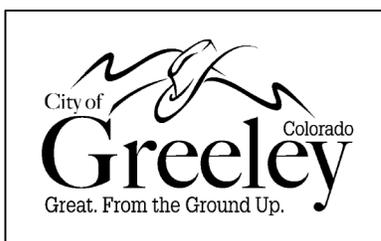
DURATION: FACTOR:	5 MIN 0.29	10 MIN 0.45	15 MIN 0.57	30 MIN 0.79	60 MIN 1.00	120 MIN	180 MIN
<b>2-YEAR</b> 1-HR DEPTH (IN): DEPTH AT DURATION (IN): INTENSITY (IN/HR):	1.04 0.30 3.62	1.04 0.47 2.81	1.04 0.59 2.37	1.04 0.82 1.64	1.04 1.04 1.04	1.16 0.58	1.25 0.42
<b>5-YEAR</b> 1-HR DEPTH (IN): DEPTH AT DURATION (IN): INTENSITY (IN/HR):	1.49 0.43 5.19	1.49 0.67 4.02	1.49 0.85 3.40	1.49 1.18 2.35	1.49 1.49 1.49	1.60 0.80	1.69 0.56
<b>10-YEAR</b> 1-HR DEPTH (IN): DEPTH AT DURATION (IN): INTENSITY (IN/HR):	1.76 0.51 6.12	1.76 0.79 4.75	1.76 1.00 4.01	1.76 1.39 2.78	1.76 1.76 1.76	1.91 0.96	2.02 0.67
<b>50-YEAR</b> 1-HR DEPTH (IN): DEPTH AT DURATION (IN): INTENSITY (IN/HR):	2.51 0.73 8.73	2.51 1.13 6.78	2.51 1.43 5.72	2.51 1.98 3.97	2.51 2.51 2.51	2.65 1.33	2.75 0.92
<b>100-YEAR</b> 1-HR DEPTH (IN): DEPTH AT DURATION (IN): INTENSITY (IN/HR):	2.78 0.81 9.67	2.78 1.25 7.51	2.78 1.58 6.34	2.78 2.20 4.39	2.78 2.78 2.78	2.99 1.50	3.15 1.05

NOTE: DEPTH AT EACH DURATION = 1 HOUR OF RAINFALL DEPTH X RESPECTIVE DURATION FACTOR

EXAMPLE FOR 5 MINUTE DURATION:

$$\begin{aligned} \text{DEPTH (IN)} &= \text{2-YEAR, 1-HR DEPTH (IN)} \times \text{FACTOR} \\ &= 1.04 \times 0.29 \\ &= 0.30 \text{ INCHES} \end{aligned}$$

REFERENCE: MILLER, J.F. AND TRACEY, R.J.  
PRECIPITATION - FREQUENCY ANALYSIS OF THE WESTERN UNITED STATES  
(NOAA ATLAS) VOLUME III - COLORADO



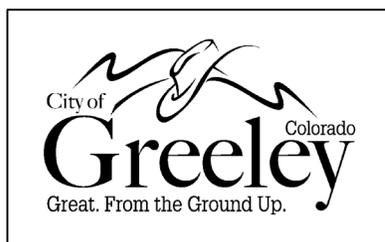
# INTENSITY - DURATION - FREQUENCY TABULATION TABLE 3-2

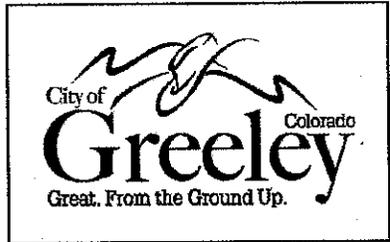
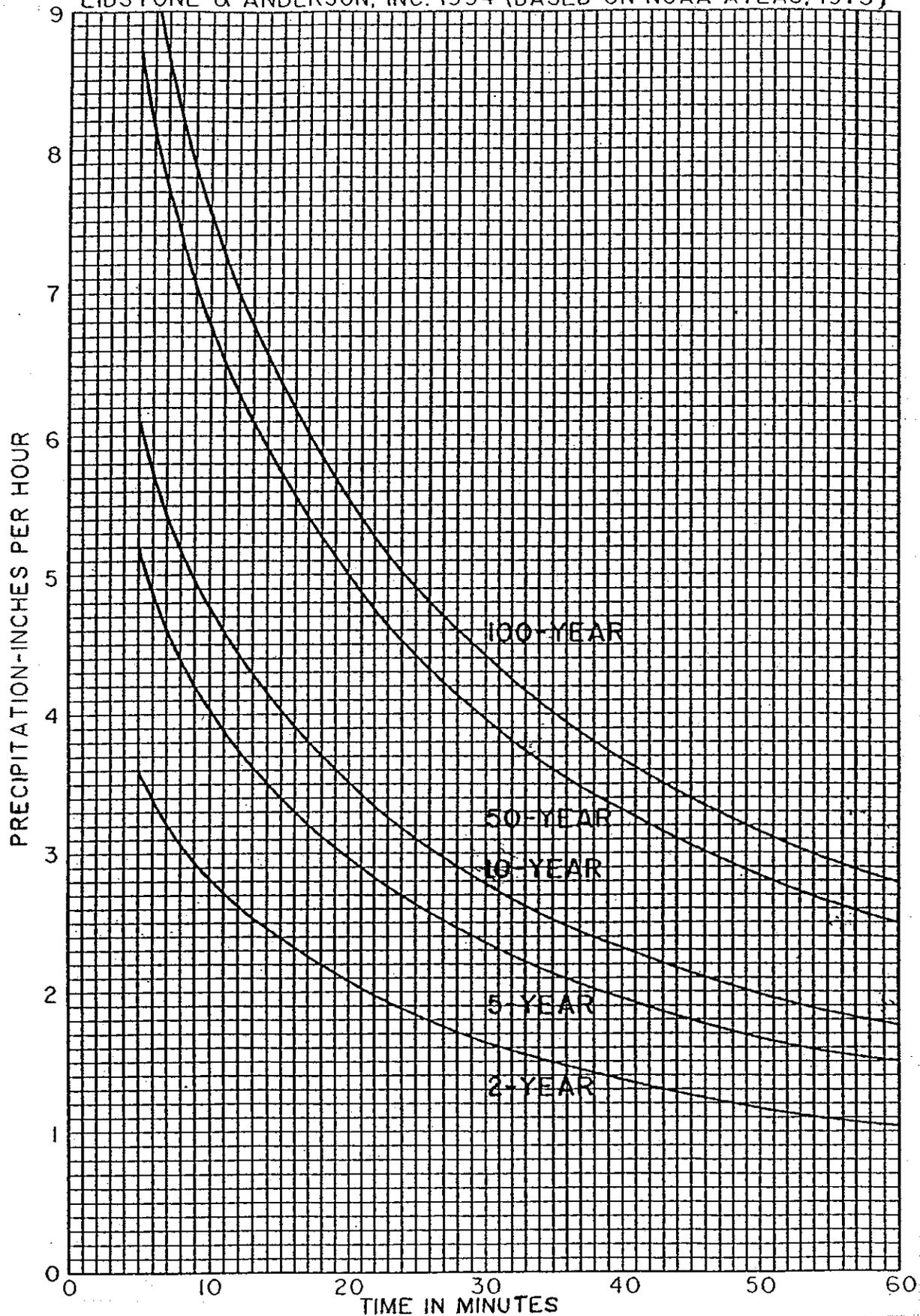
PUBLIC WORKS DEPARTMENT  
STORMWATER MANAGEMENT DIVISION  
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS  
REVISED MARCH 2007

STORM DURATION	STORM FREQUENCY					
	2-YEAR (IN/HR)	5-YEAR (IN/HR)	10-YEAR (IN/HR)	25-YEAR (IN/HR)	50-YEAR (IN/HR)	100-YEAR (IN/HR)
5 MIN	3.62	5.19	6.12	7.31	8.73	9.67
10	2.81	4.02	4.75	5.67	6.78	7.51
15	2.37	3.40	4.01	4.79	5.72	6.34
20	2.00	2.86	3.38	4.03	4.81	5.34
25	1.77	2.54	3.00	3.58	4.28	4.74
30	1.64	2.35	2.78	3.22	3.97	4.39
40	1.34	1.92	2.27	2.70	3.23	3.59
50	1.16	1.66	1.96	2.34	2.80	3.10
60 (1HR)	1.04	1.49	1.76	2.10	2.51	2.78
80	0.80	1.14	1.47	1.61	1.91	2.16
100	0.67	0.94	1.20	1.30	1.58	1.79
120 (2HR)	0.58	0.80	0.96	1.14	1.30	1.50
150	0.49	0.66	0.78	0.93	1.10	1.23
180 (3HR)	0.42	0.56	0.67	0.80	0.92	1.05
4 HR	0.33	0.44	0.53	0.62	0.72	0.81
5	0.27	0.36	0.43	0.50	0.57	0.66
6	0.23	0.30	0.37	0.43	0.49	0.57
8	0.20	0.24	0.29	0.34	0.39	0.44
10	0.15	0.20	0.24	0.29	0.32	0.36
12	0.13	0.17	0.20	0.25	0.28	0.31
14	0.11	0.15	0.18	0.23	0.24	0.27
16	0.10	0.13	0.16	0.20	0.22	0.24
18	0.09	0.12	0.14	0.18	0.19	0.21
20	0.08	0.11	0.13	0.17	0.18	0.19
22	0.07	0.10	0.12	0.16	0.16	0.17
24	0.07	0.09	0.11	0.14	0.15	0.16

**EXTENDED DURATION-INTENSITY-FREQUENCY  
TABULATION  
GREELEY, CO  
TABLE 3-3**





# INTENSITY-DURATION-FREQUENCY CURVES

PUBLIC WORKS DEPARTMENT  
STORMWATER MANAGEMENT DIVISION  
1001 NINTH AVENUE GREELEY, COLORADO 80631

FIGURE 3-1

SCALE: NTS  
REVISED AUG 1996