ORDINANCE NO. 2020-16

AN ORDINANCE AMENDING THE CITY OF BOERNE SUBDIVISION ORDINANCE NO. 2007-56, DATED NOVEMBER 13, 2007, ARTICLE 6. DRAINAGE AND FLOOD HAZARDS, SECTION 04. DRAINAGE SYSTEM DESIGN STANDARDS; AMENDING TABLE 6-5, BOERNE RAINFALL DEPTHS FOR VARIOUS DURATIONS AND FREQUENCIES

WHEREAS, on October 8, 2019 the City Council of Boerne adopted rainfall depth values, as published by the National Oceanic and Atmospheric Administration (NOAA) known as Atlas 14; and

WHEREAS, the City Council of Boerne has determined that it is in the best interest of the Boerne community to take into consideration the public health, safety and welfare to adopt the amendments included herein;

NOW THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF BOERNE, TEXAS:

The following sections of the aforementioned Ordinance are hereby amended to read:

ARTICLE 6. DRAINAGE AND FLOOD HAZARDS

SECTION 04. DRAINAGE SYSTEM DESIGN STANDARDS

6.04.002 Method of Computing Runoff.

The method of computing runoff shall be the Rational Method for watersheds of 200 acres or less in area and with time of concentration of 60 minutes or less. For watersheds with an area greater than 200 acres or time of concentration greater than 60 minutes, a computer model acceptable to the City Manager or a hydrograph method as shown in the Texas Department of Transportation (TXDOT) Hydraulic Design Manual (HDM) shall be prepared. Also when designing detention facilities or determining downstream impacts, a similar approach shall be used. In all cases, normal antecedent conditions shall be assumed unless otherwise determined by the City Manager.

A. *Rational Method.* The following parameters shall be used for runoff calculations by the Rational Method.

1. The Rational Method shall use the following formula:

$$Q = CC_f IA$$

Where:
Q = The flow at the discharge of the watershed, cubic feet per second (cfs).
C = The runoff coefficient, dimensionless, from Table 6-1 or Table 6-2
C_f = Runoff coefficient adjustment factor from Table 6-3.
I = Rainfall intensity, inches per hour, from Figure 6-1.
A = Watershed area, acres.

2. Runoff coefficients may be calculated based on specific land use established by the Zoning Districts according to Table 6-1 below, or

3. A composite runoff coefficient based on the percentages of different types of surfaces in the drainage area according to Table 6-2 below.

4. Runoff coefficients given in Table 6-1 and Table 6-2 are valid for storms up to and including the 10-year storm. Use the adjustment factor in Table 6-3 for other storm frequencies.

TABLE6-1: RATIONAL METHOD RUNOFF COEFFICIENTS BY ZONING DISTRICT				
Zoning District	**Average Impervious Cover (%)**	**Slope**		
		Up to 2%	**Over 2% & Up to 7%**	**Over 7%**
RA Single Family Residential-Agricultural	10	0.31	0.40	0.44
RMA Single Family Residential-Manor Lots	25	0.40	0.47	0.51
RE Single Family Residential – Estate	30	0.42	0.49	0.53
RE1 Low Density Single Family Residential	35	0.45	0.52	0.55
R1 Medium Density Single Family Residential	40	0.48	0.54	0.57
RN1 Neighborhood Residential	45	0.51	0.57	0.59
R2 Moderate Density Residential	50	0.54	0.59	0.62
R3 High Density Residential	60	0.60	0.64	0.66
R-4 Multi-family Residential	65	0.63	0.66	0.68
RMO Modular Residential	55	0.57	0.61	0.64
O Office	70	0.66	0.69	0.70
B1 High Density Residential & Neighborhood Commercial	80	0.71	0.73	0.74
MU1 Mixed Use District	75	0.69	0.71	0.72
B2 Highway Commercial	85	0.74	0.76	0.77
B2R Highway Commercial (Restricted)	80	0.71	0.73	0.74
MU2 Mixed Use District	75	0.69	0.71	0.72
B3 Central Business	92	0.78	0.79	0.80
RC River Corridor	90	0.77	0.78	0.79
I Industrial	95	0.80	0.81	0.81
MHC Manufactured Home Community	55	0.57	0.61	0.64

Note: Average expected impervious cover is indicated, if impervious cover of development will differ because of overlay zoning or other conditions, alternative factors may be used when justified to the satisfaction of the **City Manager** in the drainage report.

TABLE 6-2: RATIONAL METHOD RUNOFF COEFFICIENTS FOR COMPOSITE ANALYSIS	
Character of Surface	**C**
Developed Areas	
Asphaltic	0.81
Concrete or Roof	0.83
Planted – Poor Condition (grass cover on less than 50% of the area)	
Less than 2% Slope	0.37
2 – 7% Slope	0.43
More than 7% Slope	0.45
Planted – Fair Condition (grass cover on 50% to 75% of the area)	
Less than 2% Slope	0.30
2 – 7% Slope	0.38
More than 7% Slope	0.42
Planted – Good Condition (grass cover on more than 75% of the area)	
Less than 2% Slope	0.25
2 – 7% Slope	0.35
More than 7% Slope	0.40
Undeveloped Areas	
Cultivated Land	
Less than 2% Slope	0.36
2 – 7% Slope	0.41
More than 7% Slope	0.44
Pasture or Range Land	
Less than 2% Slope	0.30
2 – 7% Slope	0.38
More than 7% Slope	0.42
Forest or Wooded Land	
Less than 2% Slope	0.28
2 – 7% Slope	0.36
More than 7% Slope	0.41

TABLE 6-3: RUNOFF COEFFICIENT ADJUSTMENT FACTORS FOR RATIONAL METHOD	
Storm Frequency (years)	C_f
25	1.1
50	1.2
100	1.25

Note: Use C_f *= 1 for 10-year form frequency or less.*

5. Rainfall intensity shall be calculated as function of the time of concentration. The time of concentration shall be calculated based on its component parts and summed to determine the total time of concentration. Flow shall be assumed to begin as sheet flow, develop into shallow concentrated flow until the flow enters a drainage system where it becomes pipe flow or channel flow. Sheet flow shall not exceed a length of 300 feet. Shallow concentrated flow shall be the total between the end of the sheet flow and the beginning of a drainage system. The

following equations may be used to calculate travel time for sheet flow and shallow concentrated flow, respectively:

$$T_{Sheet} = \frac{Ln}{42S^{0.5}}$$

$$T_{Shallow} = \frac{Ln}{60S^{0.5}}$$

Where:
T_{Sheet} = Sheet flow travel time, minutes.
$T_{Shallow}$ = Shallow concentrated flow travel time, minutes.
L = Flow length, feet, maximum 300 feet for sheet flow.
N = Manning's roughness coefficient from Table 6-4.
S = Slope of ground, ft/ft.

Where hydraulic calculations can be performed to calculate the velocity in the drainage system, the calculated velocity shall be used to determine the time of concentration in the drainage system. In other cases use Manning's equation with the roughness coefficients given below to calculate the velocity in the drainage system.

TABLE 6-4: MANNING'S ROUGHNESS COEFFICIENTS FOR SHEET FLOW AND SHALLOW CONCENTRATED FLOW

Manning's "n"	Condition
0.016	Concrete (rough or smoothed finish)
0.02	Asphalt
0.1	0-50% vegetated ground cover, remaining bare soil or rock outcrops, minimum brush or tree cover
0.2	50-90% vegetated ground cover, remaining bare soil or rock outcrops, minimum- medium brush or tree cover
0.3	100% vegetated ground cover, medium- dense grasses (lawns, grassy fields etc.) medium brush or tree cover
0.6	100% vegetated ground cover with areas of heavy vegetation (parks, green- belts, riparian areas etc.) dense under- growth with medium to heavy tree growth

Use the total calculated time of concentration as the duration to determine the critical rainfall intensity from Figure 6-1. Use a minimum time of concentration of 5 minutes.

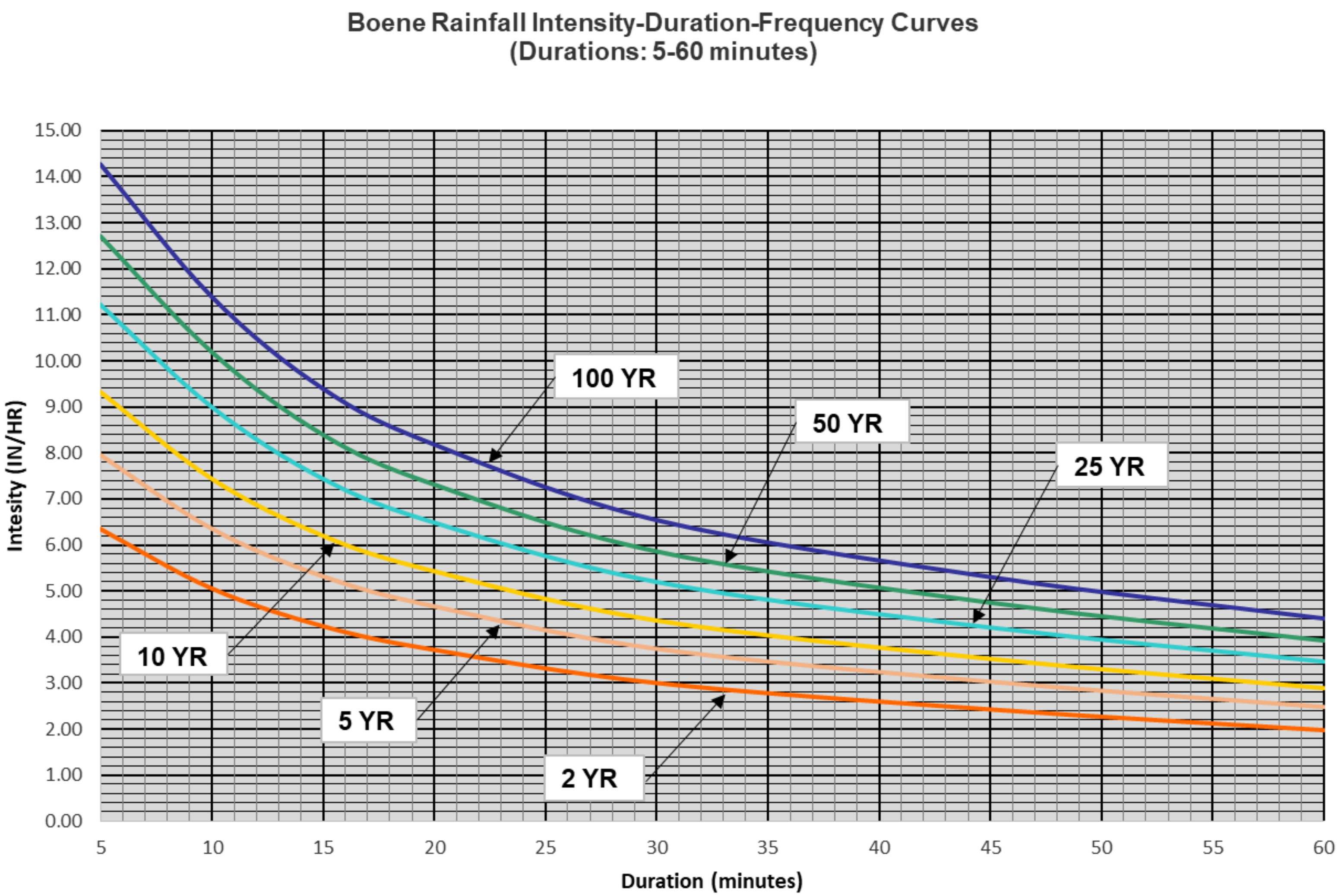

Figure 6-1 – Boerne Rainfall IDF Curves (Duration 5-60 Minutes)

B. *Computer Models.* Computer models shall be prepared using the HEC-HMS software developed by the US Army Corps of Engineers Hydrologic Engineering Center. Parameters for the model shall be determined as described herein. Rainfall and runoff relationships shall be based on the methodology and parameters provided in TR-55 Urban Hydrology for Small Watersheds (TR-55) published by the Natural Resource Conservation Service (NRCS) except as modified herein. All published Hydrology and Hydraulic models shall be used if available (FEMA, San Antonio River Authority).

i. Runoff: The TR-55 methodology shall be used for runoff calculations in HEC-HMS. Curve numbers shall be determined from the values given in TR-55 or pre-approved references by the City Manager. In addition, impervious cover values shall be estimated from aerial photos for existing conditions. For post-development conditions, the maximum anticipated impervious cover shall be used with the appropriate curve number for the development. An assumption that the initial abstraction is equal to 0.2 times the maximum soil retention per TR-55 shall be used unless calibration data is available to justify other figures to the satisfaction of the City Manager.

ii. Rainfall: Values from Table 6-5 shall be used to calculate the rainfall depth-duration-frequency relationships for the model. Rainfall distribution shall be based on the Type II distribution per TR-55.

TABLE 6-5: BOERNE RAINFALL DEPTHS FOR VARIOUS DURATIONS AND FREQUENCIES.

Duration (Minutes)	Frequency					
	2-year (Inches)	5-year (Inches)	10-year (Inches)	25-year (Inches)	50-year (Inches)	100-year (Inches)
5	0.53	0.66	0.78	0.94	1.06	1.19
10	0.84	1.06	1.24	~~1.86~~ 1.50	1.70	1.90
15	1.06	1.33	~~1.81~~ 1.55	~~2.16~~ 1.86	~~2.44~~ 2.10	2.35
20	1.24	1.56	1.81	2.16	2.44	2.73
30	1.50	1.87	2.18	2.60	2.93	3.27
45	1.82	2.27	2.65	3.16	3.56	3.98
60	1.97	2.47	2.89	3.47	3.92	4.40
120	2.43	3.09	3.69	4.56	5.28	6.06
180	2.70	3.48	~~4.23~~ 4.20	5.28	~~6.21~~ 6.20	7.23
240	2.91	3.79	4.60	5.85	6.94	8.15
360	3.16	4.14	5.09	6.53	7.79	9.22
720	3.63	4.81	5.95	7.71	9.24	11.00
1440	4.14	5.53	6.88	8.95	10.80	12.80

iii. Unit hydrograph development shall be based on the Snyder-Clark Synthetic Unit Hydrograph. The following equations and parameters shall be used unless a more precise calibration is provided and approved by the City Manager.

Use the following to compute the duration of the Unit Hydrograph:

$$t_r = \frac{t_p}{5.5}$$

Where:

t_r = Unit hydrograph duration (hours).
t_p = basin lag time (hours).

Use the following to compute the basin lag time developed by the Tulsa District Corps of Engineers and used by the San Antonio River Authority in the hydraulic modeling of the Cibolo Creek Watershed:

$$t_{lag} = C_t \left(\frac{L \cdot L_{ca}}{\sqrt{S}} \right)^{0.39}$$

Where:

t_p = basin lag time (hours).
L = Length of longest flow path in the watershed (miles).
L_{ca} = Length to the centroid along the longest flow path (miles).
C_t = Coefficient, based upon level of watershed development in the watershed.
S = average slope of the longest flow path (ft. /ft.)

The C_t coefficient is defined based on the percentage of development within the watershed by:

$$C_t = 1.4224\, e^{-0.0088x}$$

Where:

x = is the percentage of development (in percent form)

The peak discharge of the unit hydrograph shall be calculated by:

$$q_p = 380 t_{lag}^{-0.92}$$

$$C_p = \frac{q_p t_{lag}}{640} \text{ or } C_p = 0.594 t_{lag}^{0.08}$$

Where:

q_p = peak discharge of the unit hydrograph (cfs).
C_p = Snyder's peaking coefficient.
A = watershed size (sq. mi.).
t_p = basin lag time (hours).

TABLE 6-6: SNYDER'S PEAKING COEFFICIENT		
Watershed Type	**Average Watershed Slope**	**C_P**

Flat	S ≤ 0.5%	0.55
Moderate	0.5% ≤ S ≤ 1.5%	0.61
Rolling	1.5% < S ≤ 3.0%	0.71
Steep	S > 3.0%	0.80

iv. Modified Puls methodology shall be used when detailed hydraulic models are available, but Muskingum-Cunge may be used for all other methods.

6. For watersheds greater than 10 square miles, the effects of storm centering must be taken into account. Consult with city staff prior to completing the model (TXDOT HDM Chapter 4 Section 13).

7. Watershed delineation for hydrologic models must include at a minimum the subareas delineated in the City of Boerne Watershed Map. In addition, subareas shall be added to the model to effectively isolate the subject development.

PASSED and APPROVED on first reading this the ____ day of June, 2020.

PASSED, APPROVED, and ADOPTED on second reading this the ____ day of June, 2020.

APPROVED:

____
Mayor

ATTEST:

____
City Secretary

APPROVED AS TO FORM:

____
City Attorney