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Drainage Criteria Manual

2.6.0 - PROBABLE MAXIMUM STORM/FLOOD DEVELOPMENT

The purpose of this section is to describe a method for developing the Probable Maximum Flood (PMF) within the City of Austin jurisdiction. The PMF is calculated by obtaining the Probable Maximum Precipitation (PMP) for a specific storm duration and drainage area. ~~The PMP rainfall depths presented in this section were derived for the Austin area and are only applicable for designing and managing dams within City of Austin's full purpose, limited purpose and extraterritorial jurisdictions.~~ Typically, a PMF runoff model requires both a temporal and spatial distribution of the PMP. However, if the drainage area is less than 10 square miles, the spatial distribution is not required (i.e. the drainage area is considered small enough that the PMP values can reasonably be considered point rainfall values). ~~The PMP values shown in this section are valid only for drainage areas less than 10 square miles.~~

The State of Texas has the primary regulatory authority for dams in Texas. The State's Dam Safety Program is under the purview of the TCEQ and Title 30, Chapter 299 of the Texas Administrative Code contains applicable rules. The primary guidance for the analysis of dam performance during a PMF event can be found in the Hydrologic and Hydraulic Guidelines for Dams in Texas. This manual and other dam safety and maintenance manuals are available on the TCEQ's web site at https://www.tceq.texas.gov/

2.6.1 - Probable Maximum Precipitation (PMP)

~~The PMP values were derived using Hydrometeorological Report No. 52 (HMR-52) and Hydrometeorological Report No. 51 (HMR-51) per the guidance provided in the Hydrologic and Hydraulic Guidelines for Dams in Texas (January 2007) available from the Dam Safety Program at the Texas Commission on Environmental Quality (TCEQ). Table 2-8 contains a summary of PMP depths and intensities for various storm durations for drainage areas less than 10 square miles.~~

~~Table 2-8~~
~~Probable Maximum Precipitation Depths for the City of Austin~~

~~Storm Duration~~	~~Depth (in)~~
~~1 hr~~	~~17.4~~
~~2 hr~~	~~21.6~~
~~3 hr~~	~~24.9~~
~~6 hr~~	~~31.1~~
~~12 hr~~	~~37.6~~
~~24 hr~~	~~44.7~~

48 hr	50.0
72 hr	53.4
1. All values are valid for drainage areas less than 10 square miles.	
2. Do not use these depths with the Soil Conservation Service (SCS) Type III distribution. The relevant storm distributions are provided in DCM Section 2.6.2 "Probable Maximum Flood (PMF)" and were derived using the Hydrologic and Hydraulic Guidelines for Dams in Texas.	

The probable maximum precipitation (PMP) is defined by the National Weather Service as "theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year." The TCEQ has completed a statewide PMP Study for Texas to determine appropriate PMP values throughout the state. The study has a spatial resolution of approximately 2.5 square miles and considers variations in topography, climate, and storm types. This study replaces data formerly obtained from Hydrometeorological Reports (HMRs) 51 and 52. The TCEQ web site (above) provides guidance for using an online geoprocessing service to calculate PMP depths for a given drainage basin.

2.6.2 - Probable Maximum Flood (PMF)

The PMF is calculated by obtaining the PMP for a specific storm duration and a specific drainage area. To determine the PMF, each of the possible storm durations (1, 2, 3, 6, 12, 24, 48, and 72 hour storms) needs to be analyzed in order to determine the critical duration. The critical duration is the storm duration that produces the highest water surface elevation behind the dam. The PMF for each storm duration is derived using the PMP depths from the TCEQ PMP tool (see 2.6.1) Table 2-8 and using a rainfall-runoff model (i.e. HEC-HMS, TR-20).

The Soil Conservation Service (SCS) Type III distribution must not be used for PMP analyses. Instead, The the rainfall-runoff model should use the temporal distribution as provided in the Hydrologic and Hydraulic Guidelines for Dams in Texas. The temporal distribution for each storm duration has been reproduced in Figure 2-4, Appendix D. Figure 2-4 provides the temporal distribution ordinates to be multiplied by the associated storm depths for use in the various rainfall-runoff models. The runoff parameters used in the PMF model are the same as those used for runoff analyses of the more frequent storm events, with the exception of curve numbers and the temporal distribution of rainfall.

Runoff curve numbers for the PMF need to reflect the assumption that the soils will be saturated. Therefore the runoff curve number should be based on ARC III. The appropriate curve number should be chosen using the tables provided in the DCM Section 2.5.2. These are ARC II values which can be converted to ARC III values using Table 10.1 in Part 630, Chapter 10 of the National Engineering Handbook. Note that the ARC was previously referred to as the Antecedent Moisture Condition (AMC) in older NRCS publications.

8.3.3 - Safety Criteria For SWM Ponds

All ponds shall meet or exceed all specified safety criteria. Use of these criteria shall in no way relieve the engineer of the responsibility for the adequacy and safety of all aspects of the design of the SWM pond.

A. The spillway, outfall, embankment, and appurtenant structures shall be designed to safely pass the design storm hydrograph with the freeboard shown in the table below. All contributing on-site drainage areas, and off-site areas which are routed through the SWM pond, shall be assumed to be fully developed in order to properly size the spillway, outfall, embankment and appurtenant structures. Any orifice with a dimension smaller than or equal to 12 inches shall be assumed to be fully developed in order to properly size the spillway, outfall, embankment and appurtenant structures. For all spillways (especially enclosed conduits), the ability to adequately convey the design flows must take into account any submergence of the outlet, any existing or potential obstructions in the system and the capacity of the downstream system.

DETENTION POND CLASS	**DESIGN STORM EVENT**	**FREEBOARD ON TOP OF ENBANKMENT, FT**
On-site/Off-site		
Small (DA < 25 ac)	100-year	0
Large (25 ≤ DA ≤ 64 ac)	100-year	1.0
Regional DA ≥ 64 ac	100-year	2.0

B. Any hydraulic structure designed to impound storm water that has a height greater than or equal to six (6) feet at any point along the perimeter of the SWM pond is a dam and must be designed to safely pass the minimum design flood hydrograph expressed as a percentage of the probable maximum flood (PMF) as described in DCM 8.3.3.B.3 ~~75 percent of the probable maximum flood (PMF)~~ and as evidenced by certification using the statement provided in DCM 8.3.3.B.3 by an engineer licensed in the State of Texas. The certification statement may be divided into the four disciplines of hydrology, hydraulics, structural and geotechnical and independently certified.

1. The height of the hydraulic structure (dam) is measured from the top of the structure to the downstream intersection of the structure and the natural or excavated ground, whichever is lower.

   The PMF is computed by using the probable maximum precipitation (PMP) values as described in Section 2-6 of the Drainage Criteria Manual.

3. A dam as defined in DCM 8.3.3.B must be designed to pass the minimum design flood hydrograph which is the greater of:

   a. 75 percent of the PMF

   b. The percentage of the PMF as defined in Texas Administrative Code Chapter 299 Dams and Reservoirs. (Figure: 30 TAC §299.15(a)(1)(A))

~~3.~~4. Dam Safety Certification Statement:

   I [name of professional engineer] Texas license number [number] certify that the design of the dam in this set of plans can safely pass the minimum design flood hydrograph as required by the City of Austin and the State of Texas ~~75 percent of the Probable Maximum Flood~~ based on the hydrologic, hydraulic, structural and geotechnical analysis using standard accepted engineering practices.

~~4.~~5. SWM ponds that are considered dams as defined in this section of the Drainage Criteria Manual may not be designed or constructed with any trees or other woody vegetation on the dam structure or within 20-feet of the upstream or downstream toe of the dam. This 20-foot clear zone must be called out on the site plan and for City maintained facilities must be part of the drainage easement dedicated for the dam facility. The toe of the dam is the junction of the constructed dam structure with the natural ground.

~~5.~~6. SWM ponds that are considered dams as defined in this section of the Drainage Criteria Manual may not have permanent irrigation systems installed on the dam.

~~6.~~7. SWM ponds that are considered dams as defined in this section of the Drainage Criteria Manual must be vegetated with grasses that do not exceed 12-inches in height and can be mowed as frequently as weekly. Examples include Bermuda grass and buffalo grass.

~~7.~~8. SWM ponds that are considered dams as defined in this section of the Drainage Criteria Manual shall provide a fixed vertical marker on or near the emergency spillway indicating the water surface elevation relative to the top of the main embankment. The markings should be in half foot increments, viewable from the furthest point of access, and must be retroreflective as defined by the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

C. All SWM ponds shall be designed using a hydrograph routing methodology. The appropriate City of Austin rainfall distribution shall be used to determine all runoff hydrographs.

D. The minimum embankment top width of earthen embankments shall be as follows:

TOTAL HEIGHT OF EMBANKMENT, FT.	MINIMUM TOP WIDTH, FT.
0-6	4
6-10	6
10-15	8
15-20	10
20-25	12
25-35	15

E. The constructed height of an earthen embankment shall be equal to the design height plus the amount necessary to ensure that the design height will be maintained once all settlement has taken place. This amount shall in no case be less than 5% of the total fill height. All earthen embankments shall be compacted to 95% of maximum density in accordance with COA standard specifications.

F. Earthen embankment side slopes shall be no steeper than 3 horizontal to 1 vertical. Slopes must be designed to resist erosion to be stable in all conditions, and to be easily maintained. Earthen side slopes for regional facilities shall be designed on the basis of appropriate geotechnical analyses.

G. Detailed hydraulic design calculations shall be provided for all SWM ponds. Stage-discharge rating data shall be presented in tabular form with all discharge components, such as orifice, weir, and outlet conduit flows, clearly indicated. A stage-storage table shall also be provided. In all cases the effects of tailwater or other outlet control considerations should be included in the rating table calculations.

H. When designing ponds in series (i.e., when the discharge of one becomes the inflow of another), a licensed engineer in the State of Texas engineer must submit a hydrologic analysis, which demonstrates the system's adequacy. This analysis must incorporate the construction of hydrographs for all inflow and outflow components.

I. Storm runoff may be detained within parking lots. However, the engineer should be aware of the inconvenience to both pedestrians and traffic. The location of ponding areas in a parking lot should be planned so that this condition is minimized. Stormwater ponding depths (for the 100 year storm) in parking lots are limited to an average of eight (8) inches with a maximum of twelve (12 inches).

J. All pipes discharging into a public storm drain system shall have a minimum diameter of 18 inches and shall be constructed of reinforced concrete. In all cases, ease of maintenance and/or repair must be assured.

K. All concentrated flows into a SWM pond shall be collected and conveyed into the pond in such a way as to prevent erosion of the side slopes. All outfalls into the pond shall be designed to be stable and non-erosive.

8.3.4 - Outlet Structure Design

There are two basic types of outlet control structures: those incorporating orifice flow and those incorporating weir flow. Rectangular and V-notch weirs are the most common types.

Generally, if the crest thickness is more than 60% of the nappe thickness, the weir should be considered broad-crested. The coefficients for sharp-crested and broad-crested weirs vary. The respective weir and orifice flow equations are as follows:

A. **Rectangular Weir Flow Equation** (See Figure 8-2 in Appendix D of this manual)

$Q = CLH^{3/2}$ (Eq. 8-1)

Where

Q = Weir discharge, cubic feet per second

C = Weir Coefficient

L = horizontal length, feet

H = Head on weir, feet

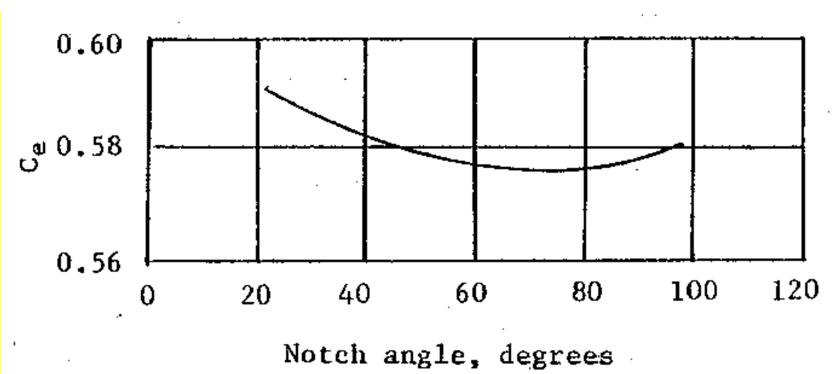
B. **V - notch Weir Flow Equation** (See Figure 8-2 in Appendix D of this manual)

Q = ~~C_v tan (0/2)$H^{2.5}$~~ $4.28\, C_e \tan(\Theta/2) H^{2.5}$ (Eq. 8-2)

Where

Q = Weir ~~Flow~~ Discharge, cubic feet per second

~~C_v~~ C_e = Weir Coefficient, $25° < \Theta < 100°$



Weir Coefficient for V-notch weir Equation 8-2

~~Θ~~ Θ = Angle of the weir notch at the apex (degrees)

H = Head on Weir, feet

C. **Orifice flow equation** (See Figure 8-2 in Appendix D of this manual)

$Q = C_o A(2gH)^{0.5}$ (Eq. 8-3)

Where

Q = Orifice Flow, cubic feet per second

C_o = Orifice Coefficient (use 0.6)

A = Orifice Area, square feet

g = Gravitation constant, 32.2 feet/sec ^{2}

H = Head on orifice measured from centerline, feet

Analytical methods and equations for other types of structures shall be approved by the Watershed Protection Department prior to use.

In all cases the effects of tailwater or other outlet control considerations should be included in the rating table calculations.