CHAPTER 8. RUNOFF CONTROL METHODS

8.1 Design Criteria for Runoff Control

Peak flow runoff controls shall be required on all land developments and redevelopments except land prepared for agricultural crops, orchards, wood lots, sod farms and nursery operations, land grading or leveling for erosion control under direction of the local soil conservation district, and land subdivisions for residential purposes with minimum lot size of 5 acres or more. When phased construction is planned or occurs, the total land area to be developed shall be considered when planning the stormwater facilities.

For all developments or redevelopments, except those exempted above, stormwater detention shall be in accordance with the Stormwater Master Plan and shall be accepted and approved by the City Engineer. Detention shall be provided to assure that the peak rate of runoff from the area after development does not exceed the peak rate of runoff from the same area before development for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year frequency, 24-hour storms. In addition, for drainage areas equal to or greater than 10 acres, if it is found that a proposed development will increase the volume of runoff from an area, the critical storm will be determined so that the peak rate of runoff from storms more frequent than the critical storm will be controlled further. The 24-hour rainfall amounts are given in Table 1-1.

The recommended method for determining the amount of runoff control is based on the size of the area under study. For sites with drainage areas less than 10 acres, the storage equation method is the preferred method. For drainage areas equal to or greater than 10 acres, the critical storm which accounts for the increase in volume of runoff must be determined before the amount of runoff control is determined by the preferred method. For sites with drainage areas between 10 and 640 acres, the graphical flow routing method, as defined in the Soil Conservation Services' Technical Release No. 55, is the preferred method. For sites with drainage areas greater than 640 acres, the Soil Conservation Services' Technical Release No. 20 Method is the preferred method. All routing calculations shall account for tailwater conditions of the receiving facility and shall be submitted to the utility.

8.2 Detention Structures

Detention structures can be categorized as: dry basins, permanent (wet) ponds, storage tanks, and multi-use storage areas such as rooftops, parking lots, roadway embankments, and other shallow holding areas. Structures for detention or retention of stormwater may be considered together since the major control structures function the same for each. The objective of control structures is to reduce peak rate of discharge by storage and controlled release. Any detention basins should be checked for compliance with Chapter 1521 of the Ohio Revised Code and the Ohio Department of Natural Resources (ODNR) Division of Water regulations and, if required, a construction permit must be obtained from the ODNR.

8.3 Design Criteria for Detention (Dry) Basins, (Wet) Ponds

1. Discharge Control Facilities

   The outlet structure shall be designed to minimize the transport of floating debris, oil, and grease through the detention facility. The design of the facility shall also include adequate provisions to minimize erosion in the vicinity of the inlet and outlet, and on the side slopes of surface facilities.

2. Detention Period

   A minimum of 50 percent of the total storage volume required to attenuate the peak discharge of the facility shall be recovered within a 24-hour time period. The remaining 50 percent shall be recovered within an additional 72-hour time period.

3. Surface Slope

   The bottom of a dry detention pond shall be at least 3 feet above the seasonal high water table. For wet ponds, the level of zero storage will be taken as the water surface elevation of the dead storage pool. The minimum bottom width for ponds and open drainage ways shall be 4 feet.

4. Stability Analysis

   Where berms constructed of fill which will be over 6 feet high are proposed, calculations supporting the stability of the fill berms are to be submitted by a Geotechnical Engineer.

5. Barriers to Access

   For fenced facilities, the maximum side slope inside the fence may be 3:1, but the maintenance berm, if required, must be a minimum of 12 feet wide all around the perimeter. Fenced facilities are discouraged.

6. Rights-of-Way and Easements

   Outfall ditches and channels shall have sufficient right-of-way for the facility plus an unobstructed maintenance berm on one or both sides. Vehicular access from a public road to the maintenance berm shall be provided. Detention facilities shall have sufficient easement to allow for the installation and maintenance of a maintenance berm. The City Engineer may require a maintenance berm all around the perimeter of the pond. If required, top widths of maintenance berms shall be 10 feet, and cross slopes shall be no steeper than 3/8-inch per foot.

7. Aesthetics

   Areas adjacent to ponds shall be graded to preclude the entrance of stormwater, except at planned locations. Where detention areas are located on the project periphery, the developer may be required to provide additional landscaping or screening to adequately protect abutting properties. Grading should take into consideration ease of maintenance, such as mowing.

8.4 Summary of Design Criteria

1. Surface Storage Criteria

A summary of the basic design criteria parameters for detention basins and parking lot storage is given in Table 8-1. They are intended to establish general limits of design and are not all inclusive. In the final analysis, engineering judgment and actual experience are important factors of any design.

Table 8-1

Summary of Design Criteria
For
On-site Detention/Retention Structures

Control Method	Inside Maximum Side Slope	Maximum/ Minimum Water Depth	Top Width of Embankment	Minimum Maintenance Berm Width
Detention (Dry) Basin	4:1	Maximum 4-6 feet	8 feet	10 feet
Detention (Wet) Pond	4:1	Minimum Pool 10 feet	10 feet	10 feet
Parking Lot Storage	--	Maximum 12 inches*	--	--

*Locate if possible in traffic isle path.

8.5 Storage Equation (Preferred Method for Determining the Storage Requirement from a Drainage Area of Less Than 10 Acres)

The storage equation method presented here can be used on drainage areas less than 10 acres. The storage equation proscribes that the required storage volume is determined by a trial and error approach based upon the 100-year post-development peak discharge for various durations minus the 100-year predevelopment peak discharge times the duration in seconds. The general procedure for flow routing by the storage equation is as follows:

Step 1. Determine the predevelopment and post-development peak discharges for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year frequency event using the Rational Method.

Step 2. Determine the required storage volume by the storage equation. The required storage for each frequency event shall equal the frequency event's post-development peak discharge divided by the 100-year post-development peak discharge times the required storage volume as determined by the storage equation (see following Example 8.5.1).

Step 3. Size the outlet facility so that for each frequency event the outlet discharge does not exceed the predevelopment discharge.

Step 4. Design the detention/retention structure according to the design criteria given in this chapter.

8.5.1 Example - Storage Equation

Determine the required storage volume for a 5-acre watershed and a pre-development runoff coefficient equal to 0.3 and a post-development runoff coefficient equal to 0.65. The time of concentration (TC) has been calculated to be 15 minutes for predevelopment conditions and 8.0 minutes for post-development conditions. Since for post-development the TC of 8.0 is less than TC of the minimum value, use 10 minutes. Because the area is less than 10 acres, the storage equation can be used. For this example, the 1-, 2-, 5-, 10-, 25-, and 50-year frequency predevelopment discharges are not to be calculated as they are not required for the storage volume although these discharges are needed to size the outlet facility.

Step 1. Use Exhibit I-1 (page 1-2) with TC pre = 15 and TC post = 10 and read predevelopment rainfall intensity I_{100} = 6.47

Post-development rainfall intensity I_1 = 3.00, I_2 = 3.90, I_5 = 4.80, I_{10} = 5.45, I_{25} = 6.36, I_{50} = 7.09, and I_{100} = 7.81

Calculate discharge Q=CIA

Predevelopment

100-year event Q_{100} pre = 0.3 x 6.47 x 5 = 9.7 cubic feet per second (cfs)

Post-development

1-year event: Q_1post = 0.65 x 3.00 x 5 = 9.8 cfs;

2-year event: Q_2post = 0.65 x 3.90 x 5 = 12.7 cfs;

5-year event: Q_5post = 0.65 x 4.80 x 5 = 15.6 cfs;

10-year event: Q_{10}post = 0.65 x 5.45 x 5 = 17.7 cfs;

25-year event: Q_{25}post = 0.65 x 6.36 x 5 = 20.7 cfs;

50-year event: Q_{50}post = 0.65 x 7.09 x 5 = 23.0 cfs; and

100-year event: Q_{100}post = 0.65 x 7.81 x 5 = 25.4 cfs.

Step 2. Calculate storage volume by the storage equation using a trial and error approach.

Duration (minutes)	I (in/hr)	CA	Qp (cfs)	Qo (cfs)	Required Storage Cubic Feet
10	7.81	3.25	25.4	9.7	9,420
12	7.21	3.25	23.4	9.7	9,864
14	6.70	3.25	21.8	9.7	10,164
16	6.26	3.25	20.3	9.7	10,176
17	6.06	3.25	19.7	9.7	10,200
18	5.87	3.25	19.1	9.7	10,152

The required storage is the largest calculated values which is 10,200 cf.

Required storage for each frequency event

1-year event (9.8/25.4) x 10,200 = 3,930 cf;

2-year event (12.7/25.4) x 10,200 = 5,100 cf;

5-year event (15.6/25.4) x 10,200 = 6,260 cf;

10-year event (17.7/25.4) x 10,200 = 7,110 cf;

25-year event (20.7/25.4) x 10,200 = 8,310 cf;

50-year event (23.0/25.4) x 10,200 = 9,240 cf; and

100-year event (25.4/25.4) x 10,200 = 10,200 cf.

8.6 Critical Storm

The critical storm is determined so that the peak rate of runoff from storms more frequent than the critical storm will be further controlled. The general procedure for determining the critical storm is as follows:

Step 1. Determine the predevelopment and post-development runoff volume for the 1-year frequency, 24-hour event.

Step 2. Calculate the percentage of increase in runoff volume by dividing the post-development runoff volume by the predevelopment runoff volume.

Step 3. Determine the critical storm from the following table:

Percentage of Increase in Runoff Volume	Critical Storm in Years
0 to >10	1
≤10 to >20	2
≤20 to >50	5
≤50 to >100	10
≤100 to >250	25
≤250 to >500	50
≤500	100

Step 4. The peak rate of runoff for both the critical storm and all storms more frequent than the critical storm shall not exceed the peak rate of runoff from a 1-year predevelopment storm. The peak rate of runoff from the area after development for storms of less frequent occurrence than the critical storm shall not exceed the predevelopment peak rate of runoff for the same frequency storm before development.

8.7 Graphical Flow Routing (Preferred Method for Determining the Storage Requirement from a Drainage Area Between 10 and 640 Acres)

The graphical method presented herein was developed by the Soil Conservation Service and is found in Chapter 7 of the Urban Hydrology for Small Watersheds, Technical Release No. 55. It is based on average storage and routing effects using the storage-indication method of routing. The graphs relate inflow (Q_i) and release rate (Q_o) to storage requirements for single or multiple stage outlet structures. Emergency spillway flow (overflow) is not considered in this method.

Use of this graph will result in rough approximation since this method is based on several general assumptions and the procedure may significantly overestimate the required storage requirements. The results of the Graphical Flow Routing method should be interpreted accordingly.

For any application where the graphical method is not appropriate, a more accurate flow routing method, such as the storage-indication method, is needed to determine storage requirements.

The following summarizes general procedures for the determination of storage capacity using the graphical flow routing method.

Step 1. Determine the post-development volume of runoff (V_r), the peak inflow discharge (Q_i), and the peak outflow discharge (Q_o) for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year frequency events using the graphical peak discharge method (see Article 2.2). Normally the peak inflow discharge equals the post-development peak discharge and the peak outflow discharge equals the predevelopment peak discharge.

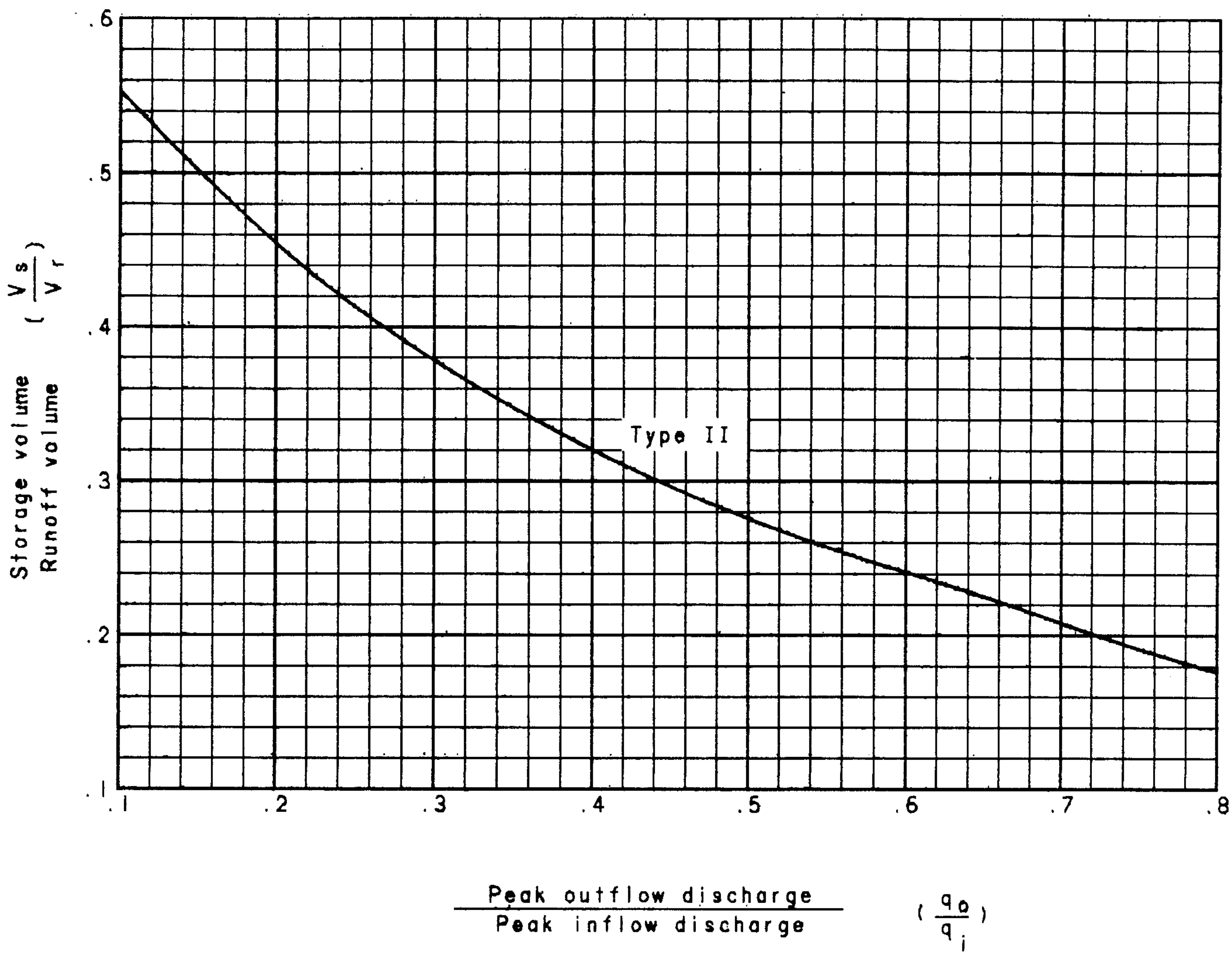
Step 2. Calculate the ratio of peak outflow discharge to the peak inflow discharge (Q_o/Q_i) accounting for critical storm for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year frequency events.

Step 3. Use Exhibit VIII-1 (page 8-8) and determine the ratio of storage volume to the post-development volume of runoff (V_s/V_r) for each event in Step 2.

Step 4. Calculate the required storage volume (V_s) $V_s = V_r \times (V_s/V_r)$. The required storage volume (V_s) is expressed in the same units as the post-development volume of runoff (V_r). If V_r is expressed in inches of runoff, the conversion to acre feet is: multiply V_r times 53.33 (the conversion factor from inches per square mile to acre feet) times drainage area in square miles. To convert acre feet to cubic feet, multiply V_r expressed in acre feet times 43,560 (the conversion factor from acre feet to cubic feet).

Step 5. Check that for each frequency event the outflow structure releases the desired rate of outflow at the corresponding storage elevation. This can be done by constructing a stage-discharge and stage-storage relationship for the outlet structure. To be a satisfactory design, the stage of each frequency event should result in a release rate that is equal to or less than the desired rate of outflow which would result in the actual storage being equal to or greater than the required storage.

Step 6. Design the detention/retention basin according to the design criteria given in this chapter.



APPROXIMATE DETENTION BASIN ROUTING