Storm Drainage Design Criteria

1. Methods for determining peak rate and design flows.

   A. The amount of rainfall runoff tributary under 200 acres to the existing and proposed storm sewers throughout the City of Delaware is based on the rational method of design. The basic formula for the rational method is Q = CIA.

      Q is the maximum rate of rainfall runoff in cubic feet per second (cfs).

      C is the runoff coefficient which is the ratio between the maximum rate of runoff from the area and the average rate of rainfall on the area during the time of concentration.

      I is the average rainfall intensity, in inches per hour, for a duration equal to the time required for the runoff to flow from the most remote part of the drainage area to the point under design. See appendix, "Rainfall Intensity Duration Curves."

      A is the drainage area in acres tributary to the point under design.

      Under the rational method, it is assumed that the rate of runoff to each point under design considerations is a function of the average rainfall rate during the time required for water to flow from the most distant part in the tributary area to the point. This time of flow is called the "time of concentration" at that point. The rational method also assumes that the peak rate of rainfall occurs within the time of concentration.

      The runoff coefficients as delineated on Plate XIX represent average values for use with the rational method.

B. **Drainage areas over 200 acres.** For drainage areas over 200 acres and for determining major storms, the method explained in "Urban Hydrology for Small Watersheds", Technical Release No. 55, latest edition, may be used to provide peak rates of runoff at the discretion of the City Engineer. Technical Release No. 55 can be obtained from the Soil Conservation Service, U.S. Department of Agriculture.

2. Design Storms

A. **Rainfall Frequency.** Rainfall frequency curves, City of Columbus, AA-D1, Relation of Rainfall Intensity vs. Time, based on records of Columbus Station U.S. Weather Bureau, 1897 to 1950, are acceptable for use in the City of Delaware and will be used for all design storms. (See Appendix for rainfall frequency curve.) The peak discharge to be computed for all storm drainage facilities used for collecting and transporting storm runoff is defined in the design criteria for those facilities.

B. **Major Storm.** A routing path for the 100-year storm shall be provided.

Drainage Area Determination

3. **The drainage area shall be determined from one or more of the following sources:**

A. U.S.G.S. maps
B. Photogrammetrics
C. Field investigations
D. Soil Survey of Delaware County
E. City of Delaware Topographical maps. Scale 1" = 200'.

4. Routing Path

A. **Capacity.** The routing path for the major drainage system is that part of the storm drainage system which carries the runoff which exceeds the capacity of the designed drainage facilities. The major drainage system shall have the capacity to carry runoff from a storm with a return period of not less than 100 years without causing significant threat to property or public safety.

B. **Surface Routing Paths.** Generally, it is not economically feasible to size a storm sewer system to collect and convey more than the frequent storm runoff. Essentially, the complete drainage system of an urban area contains two separate drainage elements. While the storm sewers belong to the initial system, surface drainageways must be provided for the major flow from more intense storms.

C. **Intent in Providing Routing Paths.** The intent of planning for the major drainage element is to ensure stormwater runoff which exceeds the capacity of the initial drainage system has a route to follow which will not cause a major loss of property or any loss of life. It should be remembered that the major drainage system exists even when it is not planned and whether or not development exists with respect to it. To get in the way of the major storm is careless and costly.

D. **Street Right-of-Way.** Street rights-of-way are a common choice for conveying major drainage flows. Again, such use must be anticipated when the street layout is established. Side and rear lot lines offer one alternative to the street. The problem with this alternative is the possibility that individual property owners may encroach on the major drainage easement. Rarely is the problem recognized until the infrequent rainstorm occurs and the major system fails to operate properly. Where the street is designated as the major drainageway, the depth of flow shall not exceed 18 inches at the gutter line for local and

collector streets and shall not exceed 6 inches of depth at the crown for arterial streets. The same maximum depth criteria will apply where a major drainageway crosses the street. Where a major drainageway is located outside of a street right-of-way, easements should be provided and a grading plan should be submitted with detailed engineering plan submission. The grading plan will include elevations along the routing path and other elevations necessary to show the major storm is contained within the planned area. The grading plan shall be submitted and filed at the office of the City Engineer.

The "Mid-Ohio Regional Planning Commission" (MORPC) Storm Water Design Manual shall be used as a reference for the calculations of the depths for the major storm.

E. **Multi-Purpose Routing Paths.** In order to protect the integrity of nonstreet drainage rights-of-way, it is effective to design routing paths for multi-purpose functions. Pedestrian, bicycle paths, and utility easements lend themselves naturally to this application. Linear parks aligned along the major drainage corridor are also very effective, but usually require greater width than would normally be necessary for drainage purposes.

F. **Major Storm Runoff.** The major storm runoff is routed through the drainage system to determine if the combined capacity of the routing path and storm sewer system is sufficient. The capacity of the conduit at any given point is assumed to be the same for the major storm as for the initial storm.

G. **Culvert Locations.** Routing of the major storm at culvert locations shall be at low areas or sags of vertical curves of streets. Elevations for the design of the street shall be such to permit the major storm to flow across the street and to prevent damage to any existing or proposed building structure.

H. **Floodplain Restrictions.** Certain limited areas of the City lie within the floodplain of the Olentangy River or its tributaries. The City shall maintain on file for public examination current maps delineating the boundaries within the City of all lands designated "100-year Floodplain" by the Federal Emergency Management Agency (FEMA). All improvements in a floodplain shall be in compliance with the City Ordinance Chapter 1150 pertaining to F-1 floodway districts.

5. Roadway Culverts

A. Design storm frequency 25 year minimum.

B. **Design Procedure.** The culvert design procedure recommended for use is "Hydraulic Engineering Circular No. 5." This circular may be obtained from the U.S. Government Bookstore located in Room 207 of the Federal Building at 200 North High Street, Columbus, Ohio 43215 or from the superintendent of Documents, U.S. Government Printing Office, Washington D.C., 20402.

C. **Design Flow.** See Section "1."

D. Maximum Allowable Headwater

1) 18 inches below top of curb.

2) 12 inches below edge of pavement.

3) Property Damage - 100-year frequency head water shall not exceed any existing or proposed building first floor elevation.

E. Manning's "n" Value

1)	Box Culvert	0.011
2)	Slab Top Culvert	0.03 to 0.05
3)	Concrete Pipe	0.013

F. Entrance Loss Coefficient

1)	Box Culvert and Slab	
	- Top Culvert	0.2 to 0.5
2)	Concrete Pipe	0.2

G. Maximum Allowable Outlet Velocity

1)	Bare Earth Channel	6 fps
2)	Rock Protection	18 fps
3)	Stilling Basin	Over 18 fps

The ability of the downstream channel to handle the flow satisfactorily must be satisfied.

H. End Protection

1) Full height headwall with flared wings.
2) Other special type headwalls must be approved before use.

I. **Structural Design.** The structural design criteria for culverts will be as required by the City of Delaware together with the State of Ohio, Department of Transportation Construction and Material Specification, including all specifications thereto.

6. Storm Sewers

A. Storm Drainage Requirements

1) **Minimum Cover.** Minimum cover for storm sewer pipe shall be 1 foot clear from the bottom of the curb and gutter or from the bottom of the underdrain to the outside top of the pipe except as approved by the City. Maintain a minimum of 2 feet of cover from the finished ground surface to the outside top of the pipe for any storm sewer system located beyond the limits of street right-of-way.

2) **Endwalls.** Standard endwalls are to be constructed at the inlet and outfall of all storm sewers, and shall be shown on the plan and profile.

3) **Erosion Control.** Erosion control shall be provided at the outfall of all storm sewers, and shown on the plan and profile. In addition, measures approved by the City shall be taken to control erosion during construction in accordance with the current Water Pollution and Sediment Runoff Control Regulations.

4) **Outfall Elevation.** The invert of the first storm sewer appurtenance shall be above the computed floodplain elevation.

5) **Minimum Size.** Pipe for storm sewers shall not be less than 12 inches in diameter.

6) **Storm Sewer Calculations.** All drainage calculations, drainage area outlines, and contributing areas used in drainage design shall be furnished.

7) **Inverts at Structures.** The inverts of all curb inlets, manholes, yard inlets, and other appurtenances shall be formed to reduce turbulence to a minimum.

8) **Surface Yard Inlets.** All surface yard inlets shall have convex castings to prevent the collection of debris.

9) **Overland Flow.** The maximum distance for overland flow shall be 300 feet before entering a surface yard inlet or 425 feet before entering a curb inlet. Except that the maximum overland drainage area tributary to any yard inlet or curb inlet shall not exceed 1.5 acres.

10) **Curb Inlets.** The satisfactory removal of surface water from curbed pavement is as important as any other phase of stormwater control. Spread of water on the pavement for the design storm is considered as the best control for pavement drainage. The design procedure recommended for use is that as described in the M.O.R.P.C. Stormwater Design Manual, Chapter 6. On combined runs of over 600 feet contributing to a sag curve, an additional inlet may be required near the low point, 0.2 + or - feet above the inlet at the sag.

a) **Design Storm Frequency.** Design storm frequency using Rational Method - 2 year storm.

b) Minimum time of concentration will be 10 minutes.

c) Roughness coefficient will be 0.015.

d) Maximum spread of flow:

i. 28-foot streets from back of curb to back of curb or less, the flow may spread to a width of 8 feet from face of curb.

ii. 28-foot to 38-foot streets from back of curb to back of curb, the flow may spread to a width of 9 feet from face of curb.

iii. Arterial routes, minimum of one lane in each direction, to remain passable to traffic.

e) **Curb Inlet Spacing:** The maximum spacing for curb inlets shall not exceed 400 feet unless approved by the City.

11) **Maximum Storm Sewer Size.** All stormwater runoff shall be conducted through storm drainage systems up to and including the equivalent of a 72-inch inside diameter pipe.

12) **Watercourse Easement.** Where an open watercourse is permitted, an easement shall be provided at least equal to the area required for the 100-year rainfall. Also, the easement shall be shown on the final plat as a "Watercourse and Utility Easement." Restrictions as to the use of this easement shall be shown on the final plat. If a plat is not recorded, a recorded easement is necessary.

13. **Intersection Drainage.** No water will be allowed to cross a street intersection unless it is carried in storm sewer.

B. Storm Sewer Design Criteria

1) **Method.** The method outlined herein will provide a general guide as to the Criteria and procedures to be used for storm sewer design.

a) The rational method shall be used for all stormwater drainage design.

$Q = CIA$, in which

Q = Quantity of stormwater runoff in cfs.

C = Coefficient of runoff as obtained from "C" Factors Map, Plate XIX.

I = Average rainfall intensity in inches per hour for the period of concentration to the point under consideration.

A = Drainage area in acres tributary to the point of concentration.

b) The following rainfall frequency curves shall be used for design:

Storm Sewer Systems - 2-year rainfall
Open Channel Flow - 100-year rainfall
Bridges and Culverts - 25-year rainfall without surcharging the roadway surface

c) Storm sewer pipe sizes are to be determined by using Manning's Formula with a minimum coefficient of roughness n = 0.13 for concrete pipe laid to proper line and grade.

2) **Minimum Velocity.** The minimum allowable velocity shall be 3 feet per second (fps) in pipe.

3) **Maximum Velocity.** The maximum allowable velocity shall be 12 fps in pipe and 7 fps for open channel flow depending on the characteristics of the channel.

4) **Easements.** Easements are required for all storm sewers on private property.

7. **Open Watercourses**

A. **General.** All open channels (natural or man-made) will be enclosed with a storm sewer when an area is developed. This policy will apply even when the open watercourse is located on a property line.

B. **Exemptions.** Exemptions may be for individual developments which, based on a 2-year design storm, would require a pipe 72 inches in diameter or larger. Exemptions may also be made for areas of heavily wooded ravines with large diameter trees

and with depth sufficient to receive the flow from storm sewers without disturbing the natural state. Exemptions may also be made for environmental reasons when there are areas with existing natural scenic drainage courses with depth and grade sufficient to receive flow from storm sewers. If exemptions are made on any project, it will be with the requirement that complete computations will be made and adequate protection be installed to prevent erosion at times of peak flow. The computations shall also ensure good flow characteristics at times of low flow. Access to storm drainage ditches and channels shall be by means of maintenance easements. Such maintenance easements shall be not less than 20 feet in width, measured horizontally from the top of the bank, exclusive of the width of the ditch or channel, and a maintenance easement of this type shall be provided on each side of a flood control or storm drainage ditch channel, or storm drainage ditch channel or similar type facility. Maintenance easements are to be kept free of obstructions. Requests for exemptions must be in writing at the time of Master Drainage Plan submission.

C. **Design Storm Frequency.** Bank full for 25-year storm.

D. **Design Flow.** See Section "1."

E. **Runoff Coefficient.** Based on Plate XIX.

F. **Allowable Velocities in New Ditches.** M.O.R.P.C., Stormwater Design Manual, Chapter 9.

G. **Allowable Velocities Existing Channels.** Ability of the channel to handle the flow satisfactorily.

H. Manning "n" Value

1)	Sod or Jute mat lining	0.05
2)	Paved lining	0.015
3)	Rock Protection	0.035
4)	Existing Lining	0.025 to 0.20

For additional values, see M.O.R.P.C. Storwater Design Manual, Chapter 9.

I. Minimum Slope

1)	Desirable for new channels	0.40 percent
2)	Absolute	0.24 percent with a minimum velocity of 2 fps based on a 2-year storm

J. Side Slopes

Desirable	4:1 (grass)
Maximum	2:1 (protected)

Gabion or grouted rock channel protection may be installed with steeper side slopes.

I. DETENTION AND RETENTION FACILITIES

In developed and developing urban and suburban areas, several means for controlling stormwater runoff could be used. This usually involves storing runoff on or below the ground surface. The following types of storage facilities may be considered for detention: roof tops, parking lots, and surface basins or ponds.

The design criteria to be utilized in determining this controlled storm-water runoff should be in accordance with Section 1115.14 under ordinance No. 82-13, "Water Pollution Control and Sediment Runoff Control Regulations." The required detention volumes should be calculated for the critical storm using Exhibit A, "Total Runoff Computation Worksheet" as provided in the appendix.