A8 Sample Calculation for Determining Required Pipe Size

Given:

Drainage Area = 27 Acres
Length of Longest Drainage Path = 1000 Feet
Drainage Path Has the Following Characteristics:
¼ Concrete Channel with Elevation Change of 3 feet
¼ Grassed Channel with Elevation Change of 5 feet
½ Overland Grass Flow with Elevation Change of 7 feet
Drainage Area Has the Following Characteristics:
$^2/_3$ Single-Family Residential with Flat Slopes
$^1/_3$ Neighborhood Business with Flat Slopes

Find:

Required Pipe Size for a Roadway Crossing Using Concrete Pipe With a Square Edge Headwall at a Slope of 1.0%

Solution:

1. Calculate Length of Concrete Channel, Grassed Channel, and Overland Grass Flow

   a. Concrete Channel: 1000' X 0.25 = 250'
   b. Grassed Channel: 1000' X 0.25 = 250'
   c. Overland Grass Flow 1000' X 0.50 = 500'

2. Use the Nomograph A1 Time of Concentration to Determine T_c

   a. L = 250' and ΔY = 3' yields T_c = 3 min.; 3 min. X 0.2 = 0.6 min.
   b. L = 250' and ΔY = 5' yields T_c = 2.5 min.; 2.5 min. X 1 = 2.5 min.
   c. L = 500' and ΔY = 7' yields T_c = 4.7 min.; 4.7 min. X 2 = 9.4 min.

   Add a, b, and c for final T_c; The minimum T_c is 5 min.; 0.6 + 2.5 + 9.4 = *12.5 min.*

3. Determine C value from Table A2 Determination of "C" Value

   a. Single Family Residential with Flat Slopes Has a Range of 0.30-0.50.
      Choose C to be 0.35
   b. Neighborhood Business with Flat Slopes Has a Range of 0.50-0.70.
      Choose C to be 0.55

   Distribute $^2/_3$ of the C Value to Single Family Residential and $^1/_3$ of the C Value to Neighborhood Business and the Final C Value will be the Sum of the Distribution

   $^2/_3$ X 0.35 = 0.23
   $^1/_3$ X 0.55 = 0.18

   0.23 + 0.18 = *0.41 = C*

4. Determine the Rainfall Intensity (I) from Table A3 Rainfall Intensity

   a. From Number 2, T = 12.5 min.
   b. Roadway Crossings Shall Be Designed for the 25-Year Return Period

      Using a Linear Interpolation, *I = 6.35 in/hr*

5. Drainage Area (A) is Given at *27 acres*

6. Determine the Peak Flow (Q) by the Equation Q = CIA

   Q = C I A

   Q = 0.41 X 6.35 in/hr X 27 acres

   Q = *70.3 cfs*

7. Determine the Required Pipe Size and Velocity from Nomograph A4 Flow Within A System

   a. Given n = 0.012 and slope = 1.0%
   b. Nomograph shows Diameter = *42 inches*
   c. Nomograph shows Velocity = *10 ft/s*

8. Determine HW/D Scale Factor from Nomograph A5 Culvert Design – Inlet Control and Calculate Headwater Depth (HW) measured from the invert of the pipe upward.

   (Note: The maximum HW/D is 1.2. If HW/D is above 1.2, the pipe size may be used, subject to approval by the Engineering Director, if adequate storage is available. If adequate storage is not available, increase the pipe by one size and obtain a new Velocity and HW/D. Repeat this process until HW/D is 1.2 or less.)

   HW/D = 1.3

   HW = HW/D X (Diameter/12)

   HW = 1.3 X (42/12) = *4.55 feet*

9. If HW in number 8 is unacceptable, increase pipe to next size and re-calculate

   a. Diameter = 48 inches
   b. Velocity = 5.8 ft/s

   HW/D = 0.95

   HW = HW/D X (Diameter/12)

   HW = 0.95 X (48/12) = *3.80 feet*

** See A9 Rational Method Pipe Design for Inlet Control