# APPENDIX H

# EXAMPLES & WORKSHEETS

# EQUATION SUMMARY
# &
# WORK PROBLEMS

## RATIONAL METHOD

**$Q$ = peak discharge/rate of runoff (cfs)**

**$C$ = runoff coefficient (dimensionless) (Table 5-2)`**

$$C = \frac{\sum (C_x \times A_x)}{A_T}$$

**$i$ = rainfall intensity (in/hr) (Plates 5-4 to 5-18, IDF curves)**

**Derived from $T_C$:**

$$Tc = \sum Tt =$$ **Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time (Plates 5-1 to 5-3)**

**$A$ = drainage area (acres)**

## GRAPHICL PEAK (TR-55) DISCHARGE METHOD

$$q_p = q_u \times A_m \times Q \times F_p$$

**Utilize TR-55 Worksheets for Calculations:**

Worksheet 2: Runoff curve number and runoff (page V-48);
Worksheet 3: Time of concentration (Tc) or travel time (Tt) (page V-49);
Worksheet 4: Graphical Peak Discharge Method (page V-50)

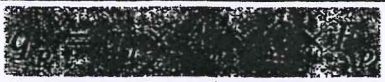
$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

- **$Q$ = runoff (inches)**
- **$S$ = Storage (dimensionless)**
- **$CN$ = Weighted Curve Number (dimensionless) (Table 5-5)**
- **$P$ = 24-hour precipitation (inches) (Plates 5-19 to 5-21)**

$$CN = \frac{\sum(CN_x \times A_x)}{A_T} \qquad S = \frac{1000}{CN} - 10$$

**$A_m$ = drainage area (sq. mi.)**

## GRAPHICL PEAK (TR-55) DISCHARGE METHOD (cont)



$q_u$ = **unit peak discharge (csm/in) (Plate 5-25)**

Derived from ratio of initial abstraction to precipitation (Ia/P) ratio and Time of Concentration (Tc)

$$I_a = 0.2 \times S$$

$$Tc = \sum Tt = \text{Overland Flow Time + Shallow Concentrated Flow Time + Channe Flow Time (as defined by TR-55, Worksheet 3, page V-47)}$$

**Overland Flow Time**

$$T_t = \frac{0.007(nL)^{0.8}}{P^{.5} S^{0.4}}$$

**Shallow Concentrated Flow Time**

$$T_t = \frac{L}{3600V}$$ Use Average Velocity (Plate 5-23)

**Channel Flow Time**

$$T_t = \frac{L}{3600V}$$ Use Manning's Velocity $$V = \left(\frac{1.49}{n}\right) \times R^{2/3} \times S^{1/2}$$

**$F_p$ = pond and swamp adjustment factor (Table 5-10)**

# OPEN CHANNEL FLOW

**Manning's Equation**

$$V = \left(\frac{1.49}{n}\right) \times R^{2/3} \times S^{1/2}$$

**Continuity Equation**

$$Q = VA$$

V = channel velocity (fps)

Q = channel discharge (cfs)

n = Manning's roughness coefficient (dimensionless) (Table 5-7)

S = channel slope (ft/ft)

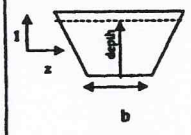
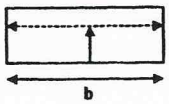
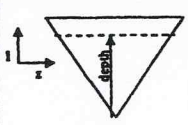
Channel Geometry:

R = hydraulic radius (A/P)

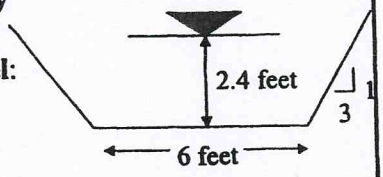
A= wetted cross sectional area

P= wetted perimeter(ft)

# Channel Geometry

| Section | Area a | Wetted Perimeter P | Hydraulic Radius R = a/P | Top Width T |
|---|---|---|---|---|
|   | $bd + zd^2$ | $b + 2d(z^2+1)^{1/2}$ | $\frac{bd + zd^2}{b + 2d(z^2+1)^{1/2}}$ | $b + 2zd$ |
|   | $bd$ | $b + 2d$ | $\frac{bd}{b + 2d}$ | $b$ |
|   | $zd^2$ | $2d(z^2+1)^{1/2}$ | $\frac{zd^2}{2d(z^2+1)^{1/2}}$ | $2zd$ |

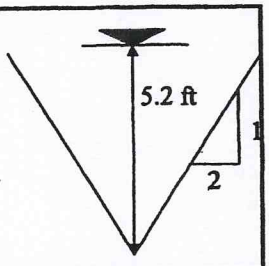
1) **Manning's Equation.** Determine the velocity and discharge at bank full flows given the following information: **Trapezoidal Channel**: Side slopes= 3:1; Bottom width = 6ft.; Bank full Depth= 2.4ft. **Channel data**: Slope= 2.0% and Mannings n value= 0.045.




**ANSWER:**

2) **Manning's Equation.**Determine Manning's n for the following channel:

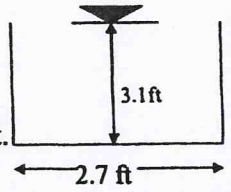
**Triangular Channel**:
Side Slopes= 2:1; Depth of Flow = 5.2 ft.
**Channel data**:
Channel Slope= 1.9%; Velocity = 5.6 ft/s




**ANSWER:**

**3) Manning's Equation:**

Determine if the 10-year discharge of 45 cfs from a new parking lot will overtop the existing channel banks given:
**Channel Data**: Rectangular Channel: Bottom width = 2.7 ft.
Depth=3.1ft., Manning's n = 0.055, Channel slope=3.4%




Answer:

**4) Runoff Curve Number Example**

Given: 45 acres B soils-Impervious
80 acres C soils Woods
15 acres A soils Open Space
130 acres D soils 1/2 Acre Residential Lots

Find Weighted CN ( *CN* )

**Answer:**

**5) Graphical Peak Discharge Example**
Given CN=76
Chesterfield County
Find $Q_{in}$ for a 2 and 10 year storm.

**Answer:**

**6) Graphical Peak Discharge Example**
Area = 1080 acres
Rainfall Distribution is Type II
Tc = 1.6 hours
Ia/P = .35
Q = 1.2 inches
Assume no pond and swamp adjustment factor

Find Peak Discharge ($q_p$)

**Answer:**