

HYDROLOGY SURFACE WATER EQUATION LIST

(1) CONTINUITY EQUATION FOR RIVER DISCHARGE

$$Q = AV = wdV = wd \frac{L}{t} = \frac{Vol}{t}$$

Where $Q =$ DISCHARGE (L^3/t)

$A =$ channel cross-sectional AREA (L^2)

$V =$ VELOCITY (L/t)

$w =$ CHANNEL WIDTH (L)

$d =$ CHANNEL DEPTH (d)

$Vol =$ VOLUME (L^3)

$t =$ time (time units)

(2) WATERSHED DRAINAGE DENSITY

$$D_d = \frac{\sum L}{A_d}$$

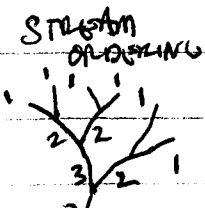
where $\sum L =$ sum of total
stream lengths (L)

$A_d =$ drainage Area
(L^2)

$D_d =$ DRAINAGE DENSITY
($L/L^2 = m/Km^2$)

(3) SHREVE MAGNITUDE FOR WATERSHEDS

$M = \sum$ frequency of first order streams



(4) RATIONAL RUNOFF METHOD (FOR WATERSHEDS)

$$Q_p = CIA \quad \text{where}$$

Q_p = PEAK RUNOFF DISCHARGE (L^3/t)

C = RATIONAL RUNOFF COEFFICIENT (dimensionless)

I = RAINFALL INTENSITY (L/t)

A_d = DRAINAGE AREA (L^2)

VALUES OF "C"

PAVEMENT $C = 0.70 - 0.95$

SANDY SOILS $C = 0.20 - 0.40$

CLAYEY SOILS/
COLLUVIUM $C = 0.40 - 0.50$

NOTE: WHERE SOILS ARE 100% SATURATED, $C \rightarrow 1.0$,
SO IN THIS CASE $Q_p = IA$

(5) FLOOD RECURRENTANCE INTERVAL

$$R.I. = \frac{n+1}{m} \quad \text{where } n = \text{TOTAL NO. OF EVENTS ON YEARS}$$

m = RANK OF EVENT,
WITH #1 = LARGEST

$$P = \frac{1}{R.I.}$$

P = PROBABILITY OF GIVEN
MAGNITUDE OF FLOOD

(6) PEAK DISCHARGE

Q_p = MAXIMUM DISCHARGE ON RECORD
(L^3/t)

Q_p DAILY = MAX. DAILY DISCHARGE

Q_p ANNUAL = MAX YEARLY Q

(7) EMPIRICAL HYDROLOGIC RELATIONS FOR
SELECT REGIONAL WATERSHEDS

(A) $Q_{max} = 38 M^{0.89} D^{-0.50}$ FOR APPALACHIAN
PLATEAU
REGION

where Q_{max} = maximum DISCHARGE (L^3/t)

M = SILLVEE MAGNITUDE (DIMENSIONLESS)

D = DRAINAGE DENSITY (L/L^2)

(B) $Q_{2.33} = 34.5 A^{0.93}$ (VERMONT
WATERSHED)

$Q_{2.33}$ = DISCHARGE WITH A 2.33 yr
RETURNANCE INTERVAL

A - DRAINAGE AREA

(8) GENERALIZED RELATIONSHIP

$Q_x = a A^b$ b range: 0.5-0.9

where x = RETURNANCE INTERVAL, Q = DISCHARGE,

A = DRAINAGE AREA, a = COEFFICIENT, b = EXPONENT.

(8) TIME FOR HYDRAULIC CONCENTRATION OF DRAINAGE BASIN

↓
 DEFINED: TIME REQUIRED DURING A STORM, FOR OVERLAND AND CHANNEL FLOW TO TRAVEL FROM THE MOST DISTANT DRAINAGE DIVIDE TO THE OUTLET OF THE BASIN

$$t_c = \frac{L^{1.15}}{7700 H^{0.38}} \quad (\text{EMPIRICAL EQUATION})$$

t_c = TIME OF CONCENTRATION (HOURS)

L = LENGTH FROM DIVIDE TO BASIN OUTLET (FT)

H = BASIN RICHNESS BETWEEN DIVIDE AND OUTLET (FT)

FLOOD FREQUENCY ANALYSIS

HOW-TO: Steps in plotting a Gumbel flood-frequency curve:

1. Count or calculate the length of record (n , in years).
2. Determine the rank (r) for each flood of record. Rank in order from greatest flood ($r = 1$) to least flood ($r = n$).
3. Determine the recurrence interval for all floods with the equation $(n + 1)/r$.
4. Select a vertical axis for plotting discharge on the Gumbel curve. This takes experience and intuition, as the vertical axis must allow for the greatest flood of record AND 200 YEAR RECURRENCE FLOODS, which are usually greater than any flood of record. As a general rule, a vertical axis in which the greatest flood of record is $1/2$ to $2/3$ of the maximum value on the vertical axis will be adequate.
5. Plot the individual flood events on the curve.
6. Fit the curve with a straight line, or 2 or 3 straight line segments. Line segments should be defined by more than 2 data.

FLUVIAL FIELD TRIP

EQUATION LIST

FROUDE NO. - DESCRIBES FLOW TYPE

$$Fr = \frac{V}{\sqrt{dg}}$$

V = velocity m/sec

d = depth in

g = gravity acc. = 9.8 m/sec^2

$F < 1$ = TRANQUIL FLOW

$F = 1$ = CRITICAL FLOW

$F > 1$ = SUPER CRITICAL FLOW

MANNING'S EQUATION - TO CALCULATE STREAM VELOCITY

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

V = VELOCITY m/sec

R = HYDRAULIC RADIUS = $\frac{A}{P}$ - A = AREA m^2

P = WETTED PERIMETER m

S = SLOPE

n = ROUGHNESS

$T_c = \gamma R S$ = CRITICAL STREAM FORCE FOR EROSION

γ = SPECIFIC WT. OF H₂O = 9800 N/m^3

R = HYDRAULIC RADIUS = $\frac{A}{P}$

S = SLOPE

STREAM POWER = KINETIC ENERGY AVAILABLE FOR WORK

TOTAL POWER $\Sigma = \gamma Q S$ (WATTS)

γ = SP. WT. H₂O = 9800 N/m^3

Q = DISCHARGE = m^3/sec

UNIT POWER $w = \frac{\gamma Q S}{w}$ (WATTS/m)

S = SLOPE

w = WIDTH m

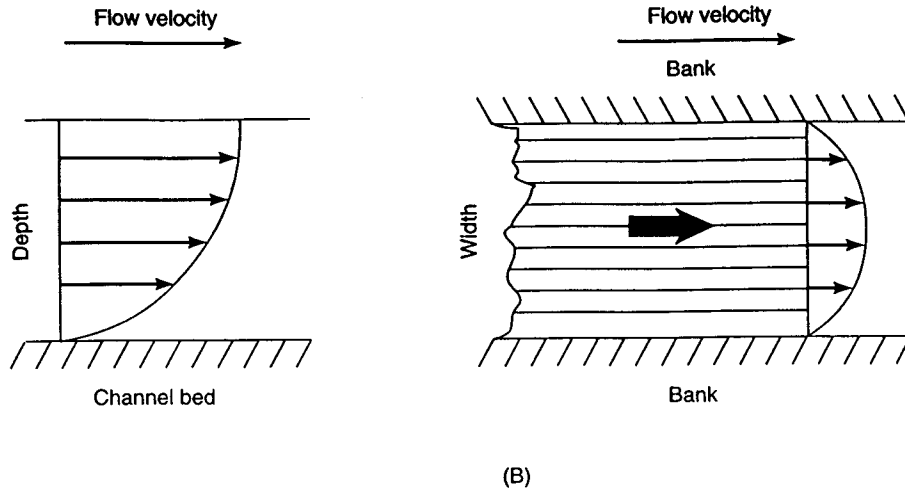
CONTINUITY EQUATION

$$Q = VA$$

Q = DISCHARGE m^3/sec

V = VELOCITY m/sec

A = AREA OF CHANNEL m^2

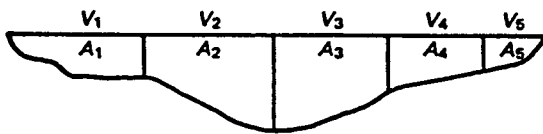


(A)

(B)

FIGURE 6.1

Diagram showing the changes in flow velocity with (A) flow depth and (B) flow width. Resistance to flow along the bed and banks allows the greatest velocities to occur toward the center of the channel near the water surface.



subareas of velocity domains.

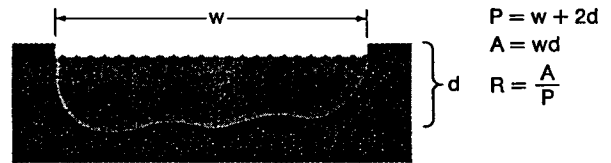
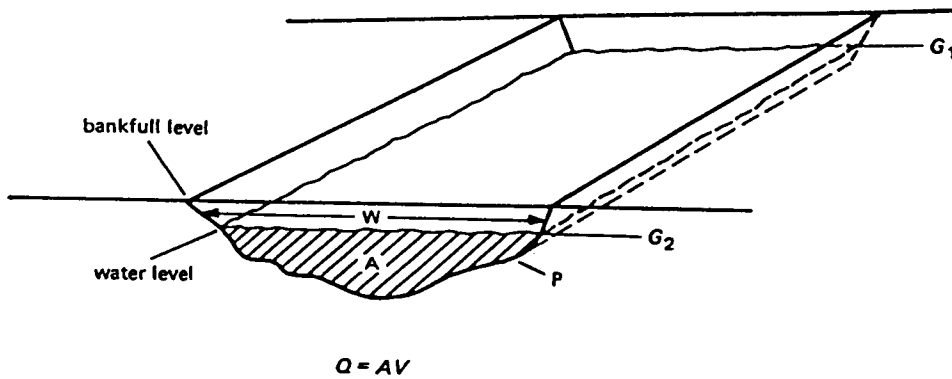


FIGURE 6.2

Cross-sectional measurements of a stream channel: w = width, d = depth, A = area, R = hydraulic radius, P = distance along wetted perimeter.



elevation
 $G_1 - G_2 = \text{fall}$
 distance from
 G_1 to $G_2 = \text{length}$
 Fall/length = gradient
 $\frac{A}{P} = R$

Figure 9.2. Nomenclature of channel morphology.

TABLE 1 - ROUGHNESSES

A. ~~TABLE 1~~ Values of Roughness, n

| River Description | Roughness, n |
|--|----------------|
| Ordinary rivers: | |
| clean, straight channel, no riffles or pools | 0.030 |
| straight, weedy, boulders | 0.035 |
| clean winding channel, pools and riffles | 0.040 |
| weedy, winding, deep pools | 0.070 |
| Alluvial channels: | |
| vegetated, no brush, grassy | 0.030-.035 |
| vegetated, brushy | 0.050-.10 |
| no vegetation | |
| ripples, dunes | 0.017-.035 |
| plane bed | 0.011-.015 |
| antidunes | 0.012-.020 |
| Mountain streams: rocky beds | |
| no vegetation, steep banks | 0.040 |
| bed of gravel, cobbles, | |
| bed of cobbles and boulders | 0.050 |

Compiled and adapted from Chow (1959 and 1964)

B.

~~TABLE 1~~ Manning roughness coefficients (n) for different boundary types.

| Boundary | Manning n (ft ^{1/6}) |
|--|----------------------------------|
| Very smooth surfaces such as glass, plastic, or brass | 0.010 |
| Very smooth concrete and planed timber | 0.011 |
| Smooth concrete | 0.012 |
| Ordinary concrete lining | 0.013 |
| Good wood | 0.014 |
| Vitrified clay | 0.015 |
| Shot concrete, untroweled, and earth channels in best condition | 0.017 |
| Straight unlined earth canals in good condition | 0.020 |
| Rivers and earth canals in fair condition; some growth | 0.025 |
| Winding natural streams and canals in poor condition; considerable moss growth | 0.035 |
| Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks | 0.041-0.050 |

Source: *Handbook of Applied Hydrology*, ed. by Ven T. Chow, copyright 1964 McGraw-Hill Publishing Co., Inc.