General Stormwater Equations

Continuity equation

$Q=VA$ or $Q=A_1V_1 = A_2V_2$

Q=volumetric flow rate (usually cfs), V= velocity (usually fps) A=cross sectional area (usually SF)

Manning's Equation for open channel

$V=1.49/n * R_h^{2/3}*S^{1/2}$ also written as $V=1.49/n * R_h^{0.667}*S^{0.5}$

V= velocity in fps, 1.49 (Imperial conversion factor), *n* = manning's roughness coefficient (from chart/table), R_h = Hydraulic Radius in feet, S= channel slope (ft/ft)

Flow Rate from Manning's Equation

Since Q=VA then $Q=VA=1.49/n *A*R_h^{2/3}*S^{1/2}$

Flow capacity of outlet

$Q=0.46/n *D^{8/3}*S^{1/2}$

D=diameter in inches = $16(q*n / S^{1/2})^{3/8}$

D=diameter in feet = $1.33(q*n / S^{1/2})^{3/8}$

Slope

$S=\triangle Elev/L$

S=Slope, $\triangle$Elev= Vertical Change in elevation (feet), L=travel distance in feet

Hydraulic Radius

$R_h =A/P$

A=Cross sectional area (SF), P= Wetted perimeter (ft) (total length that is in contact with stormwater)

Travel Time Equations - Sheet flow; Shallow concentrated flow, unpaved; Shallow concentrated flow, paved; channel or conduit flow

$T_{sheet}=(0.42*P_2^{0.5}) * (n *L / S^{0.5})^{0.8}$

$T_{unpaved}=L/(968*S^{0.5})$

$T_{paved}=L/1220*S^{0.5})$

$T_{channel}= n *L / (89.2* R_h^{0.67} * S^{0.5})$

T= travel time (minutes), L=length in feet, S=slope in ft/ft, *n=roughness coefficient,* P_2 = 2 year, 24 hours rainfall (inches)

Weir Equation (rectangular or sharp crested)

$q_w = C*L*H^{3/2}$

Q is weir (cfs), C = (discharge coefficient based on material, usually C=3.1), L= weir/notch length in feet, H = head or flow depth over weir (ft)

Orifice Equation

$q_o = CA_o\sqrt{2gh}$

Q is orifice flow (cfs), C= (discharge coefficient based on material and shape, usually C=0.60) A_o= cross sectional area (SF), g=acceleration due to gravity (32.2 ft/s^2), h = height of flow

NRCS Runoff Equation

$Q_D = (P-I_a)^2/(P-I_a+S)$ or also written $Q_D = (P-(200/CN) +2)^2 / (P+(800/CN)-8)$

Q_D=accumulated runoff depth (in.), P= rainfall in inches, I_a=Initial abstraction, S= maximum soil retention

$I_a = 0.2S$

$Q_D = (P-I_a)^2/(P-I_a+S)$

S=(1000/CN)-10 , CN=Curve Number

Natural runoff depth

$Q_N = (P-(200/CN) +2)^2 / (P+(800/CN)-8)$

Q_N=natural runoff depth (inches), P= rainfall in inches, CN=curve number (between 0 and 100)

Weighted CN (Curve number)

$CN_{avg} = \sum(CN_1*A_1)/ \sum A_1$

Weighted Q

$Q_{avg} = \sum(Q_1*A_1)/ \sum A_1$

Rational Method

$Q=C*I*A$

Q= peak flow (cfs), C= rational runoff coefficient (between 0 and 1), I = rainfall intensity inches/hour, A= drainage area (acres)

I is usually taken from an IDF chart

Detention Volume Estimates

Runoff Difference Method

$V_S=A(Q_D-Q_N)$

V_S=required storage (acre-inches), A=drainage area in Acres, Q_D= accumulated runoff depth (in.), Q_N= natural runoff depth (in.),

Post Development Runoff Volume

$V_R=3630AQ$

V_R= runoff volume in Cubic Feet, A = drainage area in Acres, Q = Runoff depth in inches

Required Storage Volume

$V_S = V_R * (V_S/V_R)$

V_S= storage volume in Cubic Feet, V_R= runoff volume in Cubic Feet, (V_S/V_R) = a regression equation based upon rainfall type, I, II, or III. We use Type II here, therefore:

$(V_S/V_R) = 0.682 – 1.43(q_o/q_1) + 1.64(q_o/q_1)^2 – 0.804(q_o/q_1)^3$

q_o/q_1 = ratio of peak flow volume (between 0 and 1)

q_o = target basin outflow, cfs

q_1 = peak basin inflow, cfs

E&S Required Sediment Zone

$V_S = 2000*A$

V_S = Volume of sediment storage in cubic feet , A = Drainage area in acres

E&S Required Dewatering Zone

$V_D = 5000*A$

V_D = Volume dewatering in cubic feet , A = Drainage area in acres