APPENDIX III

Symbols

The following symbols are used in this manual:

A = cross-sectional area of channel;
= land surface area;
= coefficient or factor;
A' = portion of A deriving its resistance from bed skin friction;
A'' = portion of A deriving its resistance from bed form drag;
A_b = area of water prism deriving its resistance from bed (determined by sidewall correction procedure);
A_w = portion of water prism deriving its resistance from walls or banks;
a = characteristic length;
= length of longest axis of particle;
= distance from stream bed at which characteristic concentration, C_a occurs;
= factor of proportionality;
a_r = dimensionless factor in logarithmic velocity equation;
B = constant in von Karman velocity equation used by Hunt;
B_s = constant in Hunt equation for distribution of suspended sediment;
b = channel width or water surface width;
= length of intermediate axis of particle;
= characteristic length;
= coefficient;
C, C' = Chezy coefficient;
$\overline{C}$ = mean value of suspended-sediment concentration in vertical;
C_a = suspended-sediment concentration at distance a above bed;
C_D = drag coefficient;
C_{hm} = Chezy coefficient for water flows with suspended sediment;
C_{hw} = Chezy coefficient for clear water flows;
C_m = coefficient in Mostafa-McDermid velocity relation;
C_m, C_w = G_s/Q = sediment discharge concentration;
C_o = maximum sediment concentration in vertical in fraction by volume;
C_v, c_v = sediment concentration, fraction by volume;
c = instantaneous suspended-sediment concentration at a point;
= length of shortest axis of particle;
$\overline{c}, C$ = mean suspended-sediment concentration at a point;
c' = fluctuating portion of suspended-sediment concentration at a point;
c_1, c_2 = dimensionless constants;
D = diameter of cylinder or pipe;
D_1, D_2 = depths of sediment deposit;
d = diameter of sphere;
= flow depth;
d' = depth of stream in Engelund's velocity equation (analogous to r')
d_g = geometric mean size of sediment;
d_n = nominal diameter of particle;
d_s = size of particle;
$d_s{}^*$ = equivalent or characteristic size of sediment;
d_{si} = mean size of ith size fraction of sediment;
d_{50} = median size of sediment (letter d with numerical subscript denotes particle size in sediment for which percentage by weight corresponding to subscript is finer, e.g., $d_{84.1}$ is size for which 84.1% by weight of sediment is finer);
F = force, submerged weight of particle or sphere;
F = $V/\sqrt{gd}$ = Froude number;
= densimetric Froude number;
F_1 = factor in Rubey equation for fall velocity of particle;

$f =$ Darcy-Weisbach friction factor;
$=$ constant factor;
$f' =$ bed friction factor for sand grain roughness or skin friction;
$f'' =$ bed friction factor for form drag;
$f_b =$ friction factor for bed determined by sidewall correction procedure;
$f_e =$ friction factor used by Engelund;
$f_f =$ friction factor for flat beds (Lovera-Kennedy);
$f_m =$ friction factor for pipes carrying sediment;
$f_w =$ friction factor for walls or banks;
$G_s =$ discharge of bed sediment;
$G_{sb} =$ bed load discharge of bed sediment;
$G_{ss} =$ suspended load discharge of bed sediment;
$g =$ acceleration of gravity;
$g_s =$ sediment discharge per unit width of channel;
$g_{sb} =$ bed load discharge of bed sediment per unit width of channel;
$g_{sbi} =$ portion of g_{sb} in ith size fraction of bed sediment;
$g_{ss} =$ suspended load discharge of bed sediment per unit width of channel;
$g_{ssi} =$ portion of g_{ss} in the ith size fraction of bed sediment;
$\overline{H} =$ mean height of ripples or dunes;
$h =$ height of ripple or dune;
$h_L =$ head loss;
$hp =$ horsepower;
$I_p =$ plasticity index for cohesive sediment;
$I_w =$ soil erodibility index;
$i =$ energy gradient for pipe flow;
$i_m =$ energy gradient for pipe flow with suspended particles;
$J =$ dimensionless parameter;
$K =$ resistance factor;
$K' =$ factor;
$K_L =$ bend loss coefficient for flow in curved channels;
$k =$ von Karman universal constant;
$= 2\pi/L =$ wave number;
$k_s =$ roughness length;
$=$ constant in Hunt's equation for distribution suspended sediment;
$k_{1-5} =$ exponents;
$L =$ wave length of ripple or dune;
$=$ length of pipe;
$l, l_1, l_2 =$ mixing lengths;
$N_1 =$ dimensionless number;
$n =$ Manning friction factor;
$=$ exponent;
$n_s =$ exponent in power relation between Q and G_s;
$n_v =$ exponent in power law relation for velocity profile;
$p =$ pressure;
$=$ wetted perimeter of channel;
$p_b =$ wetted perimeter of bed;
$p_i =$ fraction by weight of the ith size fraction of sediment;
$p_w =$ wetted perimeter of walls or banks;
$Q =$ water discharge;
$Q_s =$ sediment discharge by volume;
$q =$ flow rate or discharge of fluid per unit width of channel;
$q_c =$ critical discharge per unit width;
$q_{ci} =$ critical discharge per unit width for ith size fraction of bed sediment;
$q_s =$ sediment discharge in volume per unit width;
$q_{s*} = q_s/U_* d_s =$ dimensionless sediment discharge;
$\mathsf{R} =$ Reynolds number of flow;
$R =$ dimensionless soil-cover factor;
$R_* = U_* d_s/\nu =$ bed Reynolds number;
$r =$ hydraulic radius;
$r' =$ portion of r_b due to grain roughness or skin friction;
$r'' =$ portion of r_b due to form drag;
$r_b =$ hydraulic radius of bed (determined by sidewall correction procedure);
$r_w =$ hydraulic radius of walls or banks;
$S =$ channel slope;
$S' =$ portion of channel slope due to grain roughness;
$S'' =$ portion of channel stop due to form drag;
SF $=$ shape factor;
$S_f =$ slope of energy gradient;
$S_v =$ vane shear-strength of soil;
$s = \rho_s/\rho = \gamma_s/\gamma =$ specific gravity sediment;
$T =$ temperature;
$t, T =$ time;
$\overline{U} =$ mean velocity at vertical;
$U_* = \sqrt{\tau_o/\rho} =$ shear velocity;
$U'_* = \sqrt{\tau'_o/\rho} =$ grain-roughness shear velocity;
$U''_* = \sqrt{\tau''_o/\rho} =$ form drag shear velocity;
$U_{*c}, U_{*t} =$ critical shear velocity;
$U_{\max} =$ maximum velocity at vertical;
$U_{oc} =$ critical mean velocity near bed;
$u = \overline{u} + u' =$ instantaneous fluid velocity at a point;
$\overline{u}, U =$ mean fluid velocity at a point;
$u' =$ instantaneous turbulence fluctuation of u at a point;
$u_o =$ mean velocity near bed;
$V = Q/A =$ mean velocity;
$=$ volume of sediment;

V_B = mean velocity of sediment laden pipe flow separating flow with moving bed from heterogeneous flow;
V_c = critical velocity for entraining sediment;
V_H = critical velocity of sediment laden pipe flow dividing homogeneous and heterogeneous flow;
V_L = limiting deposit-velocity in pipe;
V_o = characteristic velocity;
v = $\overline{v} + v'$ = instantaneous component of velocity in y direction;
$\overline{v}$ = mean value of y component of velocity;
v' = instantaneous turbulence fluctuation of v at a point;
W = specific weight of sediment deposit;
w = fall velocity of particle;
= $\overline{w} + w'$
= instantaneous component of velocity in z direction;
$\overline{w}$ = mean value of velocity in z direction;
w' = instantaneous turbulence fluctuation of w at a point;
X = variable length or distance;
x = dimensionless factor in Einstein velocity relation; coordinate, usually in flow direction;
y = coordinate, usually normal to water surface (vertical);
z = coordinate, usually transverse to flow (horizontal);
= dimensionless exponent in Rouse equation for distribution of suspended sediment;
z_i = dimensionless exponent in Rouse equation based on sediment size d_{si};
z_1 = dimensionless exponent in Ippen equation for distribution of suspended sediment;
α = angle or dimensionless factor;
β = ratio, ϵ_s/ϵ_m;
$\beta_1\beta_2$ = correlation coefficient;
γ = specific weight of fluid;
γ_m = specific weight of water-sediment mixture;
γ_s = specific weight of sediment grains;
δ = Kennedy lag distance;
= lower limit of integration;
= factor in Wilson equation for velocity;
δ' = thickness of laminar sublayer;
ϵ_m = diffusion coefficient for momentum (eddy viscosity);
ϵ_s = diffusion coefficient for sediment;
ϵ_w = diffusion coefficient for water;
ϵ_x = coefficient for diffusing sediment in x direction;
ϵ_y = coefficient for diffusing sediment in y direction;
η = elevation of bed;
= efficiency of pump;
θ = angle of repose of sediment;
= dimensionless number or exponent;
λ = wave length of dune;
μ = dynamic viscosity of fluid;
μ_m = dynamic viscosity of particle-fluid mixture;
ν = kinematic viscosity of fluid;
ν_m = kinematic viscosity of particle-fluid mixture;
ρ = density of fluid;
ρ_m = density of particle-fluid mixture;
ρ_s = density of sediment grain;
σ = standard deviation of particle sizes;
σ_g = geometric standard deviation of particles sizes;
τ = shear stress;
τ_* = $[\tau_o/(\gamma_s - \gamma)d_s]$ = dimensionless shear stress or Shields parameter;
τ'_* = $[\tau'_o/(\gamma_s - \gamma)d_s]$ = portion of τ_* due to grain roughness;
τ''_* = $[\tau''_o/(\gamma_s - \gamma)d_s]$ = portion of τ_* due to form drag;
τ_b = shear stress on bed of channel;
τ_c = critical value of τ_o;
τ_{ci} = critical value of τ_o for sediment of size d_{si};
τ_i = shear stress at interface between two stratified fluids;
τ_o = bed shear stress;
τ'_o = portion of τ_b due to grain roughness;
τ''_o = portion of τ_b due to form drag;
τ_w = shear stress on walls or banks of channel;
ϕ = slope angle;
= indicates, "function of";
= Einstein's dimensionless sediment discharge;
ϕ_D = $(i_m - i)/iC_v$;
ϕ_e = Engelund's dimensionless sediment discharge;
ψ = $1/\tau_*$ dimensionless variable in Einstein $\psi - \phi$ relation;
ψ' = $1/\tau'_*$;
= particle form coefficient;
ψ'' = $1/\tau''_*$; and
ψ_d = factor in DuBoys' sediment discharge relation.