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Wetlands Research Program

Wetlands Engineering Handbook

Compiled by Donald F. Hayes, Trudy J. Olin, J. Craig Fischenich, and Michael R. Palermo

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Contents

- D E S I G N -

SECTION 3: DESIGN CRITERIA AND SITE SELECTION

SECTION 4: SUBSTRATE DEVELOPMENT, SOILS HANDLING, AND EARTHWORK

SECTION 5: ESTABLISHING PROPER HYDROLOGIC CONDITIONS

SECTION 6: WETLAND ECOSYSTEMS AND VEGETATION ESTABLISHMENT

- C O N S T R U C T I O N -

SECTION 7: SITE CONSTRUCTION AND MANAGEMENT

- M O N I T O R I N G -

SECTION 8: MONITORING AND EVALUATING SUCCESS

APPENDICES

Preface

This handbook is the end product for Work Unit 32758 under Task Area 5 of the Wetlands Research Program at the US Army Engineer Research and Development Center (ERDC). Task Area 5 was managed by Dr. Mary Landin, Environmental Laboratory (EL). Work Unit 32758 was executed by the Environmental Engineering Division, EL by Ms. Trudy Olin, Dr. Craig Fischenich, and Dr. Michael R. Palermo. Vegetation components of the handbook were coordinated by Dr. Mary C. Davis, Wetlands Ecology Group, EL. Hydrology information and techniques were coordinated by Dr. Lisa C. Roig, Hydraulics Laboratory (HL). Mr. Roy Leach, Geotechnical Laboratory (GL), coordinated sections of the handbook related to soils and geotechnical engineering. This handbook was prepared by a number of ERDC and contractor authors. Dr. Donald F. Hayes (University of Utah), Ms. Olin, Dr. Palermo, and Dr. Fischenich compiled the final handbook.

This handbookwas reviewed by Mr. Tony Dardeau (EL), Mr. Sam Collinson (CECW-OR), Mr. Dick DiBuono (CECW-EH-W), Mr. Owen Dutt (CELMS-PD), Mr. Don Dunwoody (CWMRD-CO-R), Mr. Larry Oliver (CENED-PL-L), Mr. Jake Redlinger (CENPD-CO-O), Mr. Mike Lee (CEPOD-CO-O), Mr. Don Hill (CESAC-CO-P), Mr. Dwight Quarles (CESWF-OD), Mr. Bob Blama (CENAB), Mr. Mitch Isoe (CENCD-CO-O), Mr. Rodney Woods (CEORD-CO-OF), Mr. Donnie Kinard (CESAJ-CO-OR), Mr. Larry Vinzant (CESPK-CO-R), Mr. Rob Hauch (CESWG-CO-M), Mr. Bob Gunn (CEMVN-OD-G), Mr. Ron Ventola (CEMVN-OD-G), Mr. Neal McLellan (Hartman and Associates), Ms. Monica Chasten (CENAP-EN-H), and Mr. John McCormick (CENAP-EN-H). These reviewers provided valuable suggestions and contributed materially to the final product.

Mr. Norman Francingues provided overall supervision of this project as Chief, Environmental Engineering Division, EL. Dr. John Keeley, Director, EL, provided general supervision. Dr. Russell Theriot provided overall technical guidance as Program Manager, Wetlands Research Program.

At the time of publication of this handbook, Dr. Lewis E. Link was Acting Director of ERDC, and COL Robin R. Cababa, EN, was Commander.

Symbols

ΔS = change in water storage in the wetlands impoundment, m^3
P = direct precipitation on the wetland impoundment, m^3
I_r = runoff through overland flow into the wetland, m^3
I_s = streamflow directly into the wetland, m^3
I_f = inflow from adjacent stream flooding, m^3
G_i = wetland inflow from groundwater, m^3
T_i = tidal inflows, m^3
P_i = inflow from pumping, diversions, or other artificial water source, m^3
E = evaporation from the wetland surface, m^3
T = transpiration, m^3
O_s = outflow from streams leaving the wetland, m^3
O_f = overland outflow due to wetland flooding, m^3
G_o = groundwater percolation below the root zone, m^3
T_o = tidal outflows, m^3
P_o = outflows from pumping, diversions, or other artificial sinks, m^3
n = size of sample (number of sample units) required
s = sample standard deviation
t = a factor obtained from Statistical Tables of t
E = maximum acceptable error between the sample average and the unknown population average
R = the range of values from samples obtained (i.e., the maximum test value minus the minimum test value)
s_o^2 = overall measurement variance
s_q^2 = variance due to material quality (i.e., the combined variance due to material composition and placement process variability)
s_t^2 = variance due to the testing process.
q_{ult} = ultimate bearing capacity, kPa
c = cohesion (50 percent of unconfined compressive strength), kPa
σ = normal force on the shear plane, kPa
u = pore water pressure, kPa
$\tan \phi$ = coefficient of internal friction, unitless
Q = flow rate, m^3/sec
C = discharge coefficient, $m^{0.5}$/sec
L = the effective horizontal length of the weir in feet, m
h = the height of the energy line above the weir in feet, m
V = horizontal velocity of flow, m/sec
g = gravitational acceleration, m/sec^2
HGL = hydraulic grade line
EGL = energy grade line
W_L = actual weir length, m

W_L' = actual weir length, m
ΔW_L = change in weir length (note that all changes *shorten* the weir length), m
$W_{obstruction}$ = width of weir obstruction at widest point, m.
U = wind speed, m/sec
U_A = wind stress, m/sec.
H = wave height, m
d = water depth, m
F = wind fetch, m.
T = wave period, sec.
W = weight of an individual armor stone (N)
H = wave height (m)
S_r = specific gravity of the armor stone, unitless,
cot θ = slope of the structure expressed as horizontal units / vertical unit
K_D = stability coefficient
w_r = unit weight of the rock (N/m^3)
w_w = unit weight of water (N/m^3)
D_{30} = riprap size of which 30 percent is finer by weight, m
S_f = safety factor, unitless
C_s = stability coefficient for incipient failure, thickness
D_{85}/D_{15} = gradation uniformity coefficient
C_v = vertical velocity distribution coefficient
R = centerline radius of bend
W = water surface width at upstream end of bend
C_T = blanket thickness coefficient
d = local depth of flow
γ_w = unit weight of water
γ_s = unit weight of stone
V = local depth averaged velocity
g = gravitational constant
K_1 = side slope correction factor
N_s = stability number (lower value more stable), unitless
H_s = significant wave height, m
D_{50} = median stone diameter, m
w_r = unit weight of the stone, g/cm^3
w_w = unit weight of water , g/cm^3 (fresh water: 1.000 g/cm^3, seawater: 1.025 g/cm^3)
L_o = deepwater wavelength, m
H_s = deepwater significant wave height, m.

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