Appendix I
Notation

	a	Undular wave height above initial depth, ft, maximum length of revetment stone
*	a_n	End area associated with subdivided area n *
*	A	Cross-sectional area, ft^2; total end area of cross section *
	A_a	Cross-sectional area of upstream section, ft^2
	A_b	Cross-sectional area of downstream section, ft^2
*	A_i	End area of subdivided area *i*, subsection *i* *
	A_p	Cross-sectional area of pier obstruction, ft^2
*	A_r	Iwagaki coefficient for rough flow *
*	A_s	Iwagaki coefficient for smooth flow *
	A_1	Cross-sectional area of upstream channel, ft^2
	A_2	Cross-sectional area of channel within pier, section, ft^2; cross-sectional area of downstream channel, ft^2
	A_3	Cross-sectional area of downstream channel, ft^2
	b	Channel bottom width, ft
	b_c	Confluence width, ft
	b_m	Average depth of flow at midpoint of the confluence, ft
	b_1	Upstream channel bottom width, ft
	b_3	Downstream channel bottom width, ft
	c	Maximum dimension of revetment stone parallel to the short axis
	C	Chezy's resistance coefficient; superelevation formula coefficient; weir coefficient; critical depth over crest
	$\bar{C}$	Ratio of experimentally determined air volume to air plus water volume
	C_c	Contraction coefficient
	C_e	Expansion coefficient
	C_s	Stability coefficient
	C_T	Thickness coefficient
	C_V	Vertical velocity distribution coefficient
	C_1	Correction for unit stone weight other than 165 pcf
	C_2	Correction for side slope angle
	d	Depth of flow, ft
	d_a	Depth of air-water mixture, ft
	d_c	Critical depth of flow, ft
	d_w	Experimental water flow depth, ft
	$D_{\%}$	Equivalent-volume spherical stone diameter, ft
	D_{30}	Riprap size of which 30 percent is finer by weight, ft
	D_{90}(min)	Size of stone of which 90 percent of sample is finer, from minimum or lower limit curve of gradation specification, ft
	f	Darcy-Weisbach resistance coefficient
	F	Froude number
*	F_g	Grain Froude number *
	F_1	Froude number in upstream channel of a rectangular channel contraction
	F_2	Froude number at intersection of wave fronts in transition of rectangular channel contraction
	F_s	Froude number for limit of stable flow

g Acceleration due to gravity, ft/sec^2

h_f Energy loss due to friction, ft

h_1 Head loss between cross sections, ft

H Total energy head, ft

H_e Total specific energy of flow, ft

k and k_s Effective roughness height, ft

k_c Critical value of effective roughness height, ft

* K Coefficient in Strickler's equation, ft; total conveyance in cross section *

* K_i Conveyance in subdivided area i, subsection i *

K_1 Side slope correction factor

L Length of channel transition, ft, length of spillway crest, ft

L_m Length in model, ft

L_p Length in prototype, ft

L_r Length ratio, model-to-prototype

L_s Length of spiral transition, ft

L_1 Distance from beginning of transition to intersection point of wave fronts, ft

L_2 Distance from end of transition to intersection points of wave fronts, ft

m Total hydrostatic force of water in channel
* cross section, lb; air-water ratio; ratio for meandering *

m_1 Total hydrostatic force of water in upstream channel cross section, lb

m_2 Total hydrostatic force of water in pier section, lb

m_3 Total hydrostatic force of water in downstream channel cross section, lb

m_a Total hydrostatic force of water in channel upstream section, lb

m_b Total hydrostatic force of water in channel downstream section, lb

m_p Total hydrostatic force of water on pier ends, lb

M Momentum per unit time, lb-sec/sec

n Manning roughness coefficient, ft

* n_b Base n value *

* n_i n value in subdivided area i, subsection i *

* n_N n value in subdivided area n *

n_r Ratio of Manning's n, model-to-prototype

* n_1 Addition for surface irregularities *

* n_2 Addition for variation in channel cross section *

* n_3 Addition for obstructions *

* n_4 Addition for vegetation *

* $\bar{n}$ Composite n value for the section *

* N Last subdivided area in the cross section *

* p_N Wetted perimeter in subdivided area n *

P Total wetted perimeter in the cross section

P_1, P_2, P_3 Hydrostatic pressure forces acting on the control volume at the reference sections, lb

P_f total external force of frictional resistance along the wetted surface, lb

q Flow rate (discharge) per unit width of channel, ft^3/sec/ft

Q Total flow rate, discharge, cfs

Q_n Discharge in subsection, cfs

Q_T Total discharge, cfs

* Q_{tmcb} Discharge producing a stage near the tops of the midchannel bars *

r Center-line radius of bend, ft

r_L Radius of left channel wall, ft

r_R Radius of right channel wall, ft

r_{min} Minimum center-line radius of channel bend, ft

R Hydraulic radius, ft; center-line radius of bend, ft

* $\bar{R}$ Mean hydraulic radius *

* R_c Average hydraulic radius for the entire cross section *

* R_i Hydraulic radius of subdivided area *i*, subsection *i* *

R_n Reynolds number

* s_s Specific gravity of sediment particles *

* S Sine of angle of chute inclination; slope of bed *

S_c Critical slope, ft/ft

S_f Friction slope, i.e., slope of energy grade line, ft/ft; safety factor

S_o Slope of channel invert, ft/ft

S_r Ratio of model slope to prototype slope

T Thickness of riprap revetment, ft; sill submergence

U Unknown reaction force exerted by the walls of the lateral in the upstream direction

* U_* Boundary shear velocity, fps *

* V Average flow velocity, fps; velocity of flow, fps; local depth-averaged velocity, V_{SS} for side slope riprap, length/time *

$\bar{V}$ Flow velocity in subsection, fps

V_{AVG} Average channel velocity at upstream end of bend, fps

V_c Critical flow velocity, fps

V_{SS} Characteristic velocity for side slope equal to local average velocity over slope at a point 20 percent of the slope length up from toe of slope, fps

* V_{tmcb} Average channel velocity at the top of midchannel bars *

W Channel width at elevation of center-line water surface, ft; water-surface width, ft; weight of the water in the control volume

$W_{\%}$ Weight of individual stone having diameter of $D_{\%}$, lb

X Longitudinal distance from beginning of expansion, ft

y Flow depth in straight channel, ft

y_r Vertical scale ratio, model-to-prototype

$\bar{y}$ Distance from water surface to center of gravity of the flow section, ft

y_1 Flow depth in upstream channel of rectangular channel contraction, ft

y_2 Flow depth in transition at wave front intersection of rectangular channel contraction, ft

Z Side slope, horizontal to vertical, ft/ft; transverse distance from channel center line, ft

α Energy correction factor; angle of the channel slope (tan α = channel slope); velocity head correction factor

α_1 Wave front angle from upstream channel wall in rectangular channel transition, deg

α_2 Wave front angle from downstream channel wall in rectangular channel transition, deg

β Momentum correction coefficient; wave front angle

* γ and γ_w Specific weight of water, pcf

γ_s Saturated surface dry specific weight of stone, pcf

Δb_3 Required increase in channel width

Δh_v Velocity head change from upstream to downstream of transition, ft

ΔP_1 Component in the main channel direction of the hydrostatic pressure acting over the width

Δy Superelevation of water surface in channel bend, ft

ζ Depth-width ratio

θ Angle of side slope with horizontal, deg; wave-front reflected angle, deg; wall deflection angle in rectangular channel transition, deg; angle of intersection of the junction of side channel with main channel, deg

ν Kinematic viscosity of water, ft^2/sec

ξ Flow function, $Q/b^{5/2}$

σ Geometric standard deviation of the sediment mixture

ϕ Angle of repose of riprap material, deg *