properties is sufficiently small enough that the use of the uniform flow theory will yield sufficiently accurate results.

Manning's equation is the fundamental formula for performing open-channel capacity calculations.

$$Q = A\left(\frac{R^{2/3}S^{1/2}}{n}\right)$$

Equation 1.3: Manning's equation

Where:

Q = (V)(A) = flow rate (m^3/second)
V = average flow velocity (m/second)
A = cross sectional; areas of flow (m^2)
R= hydraulic radius = cross sectional area of flow divided by the wetted perimeter (m)
S =slope of energy line (m/m)
n = Manning's roughness coefficient (refer to Table A5-4: for more additional information.

Manning's equation is used to determine the velocity of flow at a specific point in the channel therefore the variables in the equation must be representative of the point being assessed. Choice of an appropriate value for Manning's roughness coefficient for the design of an open channel is critical and requires a considerable degree of judgement. Commonly accepted values for Manning's roughness coefficient (**n**) are provided in Table A5-4.

Table A5-4: Average values of manning's roughness coefficient (n) for channels

Type of Channels	'n' value
Unlined channels	
Clay or silt	0.023
Sand	0.020
Gravel	0.030
Rock	0.040
Lined channels	
Rock riprap (loose, graded with tamped	0.035
Portland cement concrete	0.014
Air blown mortar (trowelled)	0.012
Air blown mortar (untrowelled)	0.016
Grouted rock (smooth surface)	0.014
Asphalt concrete	0.015
Pavement and gutters	
Portland cement concrete	0.015
Asphalt concrete	0.016

For additional design considerations and procedures, the Design Engineer shall refer to the FHWA publication HDS 4 .

A5.2. Cross Drainage

Cross drainage involves the conveyance of surface water and stream flow across or from the highway ROW. This is accomplished by providing one of the following: