Normal Flow in Open Channels

The hydraulic radius is defined by:

$$R_h = \frac{A}{P}$$

Manning's equation gives for the bulk velocity:

$$V = \frac{1}{n} R_h^{2/3} S^{1/2}$$

The quantity of flow is:

$$Q = VA$$

The mean depth is:

$$\bar{h} = \frac{A}{b_s}$$

The Froude number is

$$\mathrm{Fr} = \frac{V}{\sqrt{g\bar{h}}}$$

The variables are:

R_h = hydraulic radius;
A = cross-sectional area;
P = wetted perimeter;
V = average velocity;
n = Manning's roughness parameter;
S = slope (i.e. gradient);
Q = quantity of flow;
h = depth of flow;
$\bar{h}$ = mean depth;
b_s = width of water surface
Fr = Froude number

Geometric variables for various channel shapes are given in the table below.

Shape	***P***	***A***	$\bar{h}$	**Comments**
Very wide	–	h	h	Q = flow per unit width.
Rectangular	$w + 2h$	wh	h	w = width
Trapezoidal	$b + \frac{2h}{\sin\theta}$	$bh + \frac{h^2}{\tan\theta}$	$h\left(\frac{b + h\cot\theta}{b + 2h\cot\theta}\right)$	b = base width θ = side angle (from horizontal)
V-shaped	$\frac{2h}{\cos\alpha}$	$h^2 \tan\alpha$	$\frac{1}{2}h$	α = semi-vertex angle
Circular	$2R\phi$	$R^2(\phi - \sin\phi\cos\phi)$	$\frac{R}{2}\left(\frac{\phi}{\sin\phi} - \cos\phi\right)$	R = radius ϕ = semi-angle subtended by fluid ($h = R - R\cos\phi$)