Hydraulics 110401356

Shear stress: $\tau = \rho g(A/P)S_o$

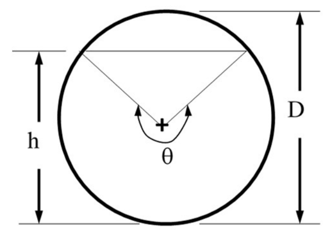
Hydraulic radius: R = A/P

Chezy equation for velocity: $V = C\sqrt{R}\sqrt{S_o}$

Chezy coefficient: $C = \frac{1}{n}R^{1/6}$

Manning equation for velocity: $V = \frac{1}{n}R^{2/3}\sqrt{S_o}$

Manning equation for flow: $Q = \frac{1}{n}AR^{2/3}\sqrt{S_o}$



Flow rate: Q = v×A

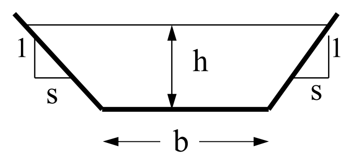
Circular channel flow area: $A = \left(\frac{\pi\theta}{180} - \sin\theta\right)\frac{D^2}{8}$ (θ in degrees)

Circular channel flow wet perimeter: $P = \frac{\pi\theta}{180}\frac{D}{2}$

Wide rectangular channel: R = h

Flow per unit width: q = Q/b

Manning *n* for composite section: $n_{avg} = (\sum_{i=1} P_i n_i^2 / P_{total})^{1/2}$



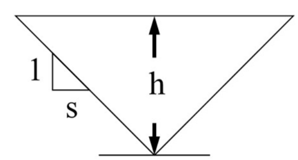
Best hydraulic section for rectangular channel: b = 2h

Best hydraulic section for trapezoidal channel: $b = 2h\sqrt{1+s^2} - 2sh$

Best hydraulic section (Q_{max}) for circular channel: h = 0.95D

Best hydraulic section (V_{max}) for circular channel: h = 0.81D

Best hydraulic section for triangular channel: s = 1



Total energy (m): $E = z + \frac{p}{\rho g} + \frac{v^2}{2g}$

Specific energy (m): $E = h + \frac{v^2}{2g}$

At critical flow: $1 = \frac{Q^2 T_c}{g A_c^3}$

Froude #: $Fr^2 = \frac{Q^2 T}{g A^3}$ or $Fr = \frac{v}{\sqrt{g h_m}}$

Mean hydraulic depth: $h_m = A/T$

For rectangular channel: $h_c = \left(\frac{q^2}{g}\right)^{1/3}$

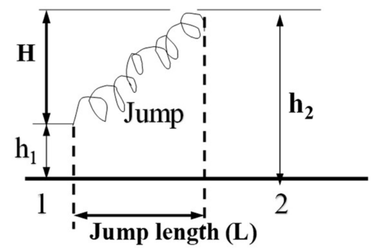
Subcritical flow: $h > h_c$, $v < v_c$, $S_o < S_c$, $Fr < 1$

Critical flow: $h = h_c$, $v = v_c$, $S_o = S_c$, $Fr = 1$

Supercritical flow: $h < h_c$, $v > v_c$, $S_o > S_c$, $Fr > 1$

Broad crested weir: $Q = 1.705 C_d \times b \times H^{3/2}$ and $C_d = Q/Q_{th}$

Jump height: $H = h_2 - h_1$



Conservation of momentum (Jump): $\rho Q v_1 + \bar{P}_1 A_1 = \rho Q v_2 + \bar{P}_2 A_2$

For rectangular channel, flow height after the jump: $h_2 = \frac{h_1}{2}\left(\sqrt{1 + 8Fr_1^2} - 1\right)$

For rectangular channel, flow height before the jump: $h_1 = \frac{h_2}{2}\left(\sqrt{1 + 8Fr_2^2} - 1\right)$

For rectangular channel, energy loss over the jump: $h_L = \frac{(h_2 - h_1)^3}{4 h_1 h_2}$

Non-uniform flow, slope of water surface: $\frac{\Delta h}{\Delta x} = \frac{S_o - \bar{S}_f}{1 - Fr^2}$

The friction slope: $\bar{S}_f = \left(n\,\bar{v}/\bar{R}^{2/3}\right)^2$

Control points (CP): at transition from subcritical to supercritical, under sluice gate, above broad crested weir, at free over-fall, at dam site and at the entrance and exit of a lake.

Direct step method: $\Delta x = \frac{E_1 - E_2}{\bar{S}_f - S_o}$ and Δx is +ve with the flow direction

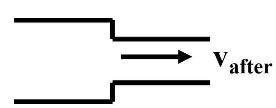
Standard step method: $E_2 = E_1 + (S_o - \bar{S}_f)\,\Delta x$ and $E_2 = h_2 + v_2^2/2g$

Darcy equation: $v = \sqrt{\frac{8g}{f}}\sqrt{R}\sqrt{S_f}$

Hydraulic grade line: $HGL = z + p/\rho g$

Pipe cross section area: $A = \frac{\pi}{4} D^2$

Energy loss (major loss) due to pipe friction: $h_L = \frac{fL}{D}\frac{v^2}{2g}$ or $h_L = \frac{fLQ^2}{12.1 D^5}$



Minor energy loss due to sudden contraction: $h_L = 0.5\frac{v_{after}^2}{2g}$

Minor energy loss due to sudden expansion: $h_L = \frac{(v_{before} - v_{after})^2}{2g}$

Minor energy loss due to pipe bend/fitting: $h_L = K\frac{v^2}{2g}$

Reynold #: $Re = \frac{vD}{\upsilon}$

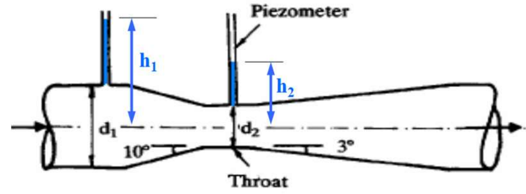
Moody equation: $f = 0.0055\left[1 + \left(20000\frac{k_s}{D} + \frac{10^6}{Re}\right)^{1/3}\right]$

Hazen-William equation: $v = 0.849 C R^{0.63} S_f^{0.54}$

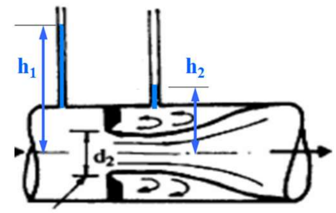
Pipe flow correction in network: $\Delta Q = \frac{-\sum h_L}{2\sum \frac{h_L}{Q}}$

Head loss: $KQ|Q|$ and $K = \frac{fL}{12.1D^5}$

Flow through Venture meter: $Q = C_d A_1 \sqrt{\frac{2g(h_1 - h_2)}{(A_1/A_2)^2 - 1}}$



Flow through small orifice: $Q = C_d A_1 \sqrt{\frac{2g(h_1 - h_2)}{(A_1/A_2)^2 - 1}}$



Pump hydraulic power (watt): Pow = ρgQH

Pump efficiency: $\varepsilon = \frac{\rho gQH}{\text{Input power}}$

Specific speed for pump selection: $Ns = \frac{NQ^{1/2}}{H^{3/4}}$

Pump type	Ns
Centrifugal	10 – 70
Mixed flow	70 – 170
Axial flow	110 and above

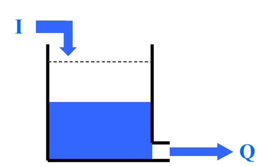
Affinity laws (N is the variable): $\frac{Q_A}{N_A} = \frac{Q_B}{N_B}$ $\quad \frac{H_A}{N_A^2} = \frac{H_B}{N_B^2}$ $\quad \frac{Pow_A}{N_A^3} = \frac{Pow_B}{N_B^3}$

Affinity laws (D is the variable): $\frac{Q_A}{D_A^3} = \frac{Q_B}{D_B^3}$ $\quad \frac{H_A}{D_A^2} = \frac{H_B}{D_B^2}$ $\quad \frac{Pow_A}{D_A^5} = \frac{Pow_B}{D_B^5}$

Pump total head (only delivery pipe is considered): $H_t = H_s + \frac{f_d L_d Q^2}{12.1 D_d^5}$

Net positive suction head: $NPSH = H_{atm} - H_{vap} - S_h - \Sigma h_{Lsuction}$

H_{vap} (m)	T(°C)
0	0
0.2	20
0.8	40



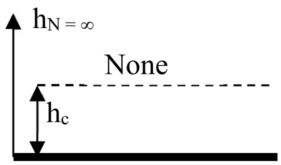
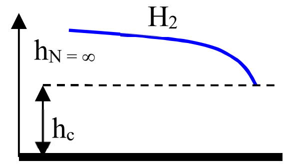
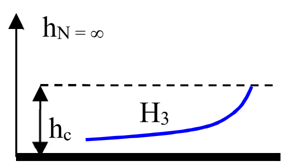
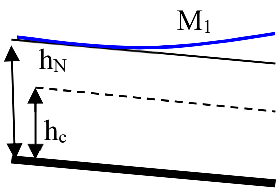
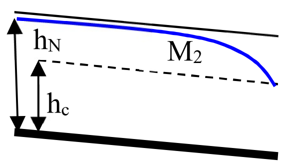
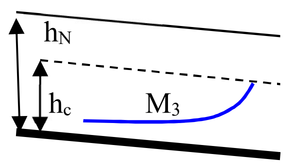
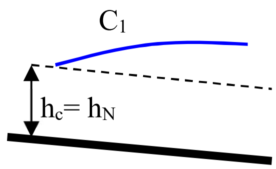
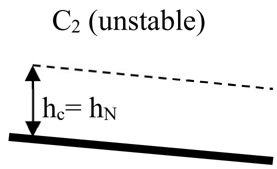
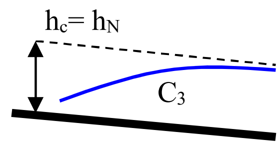
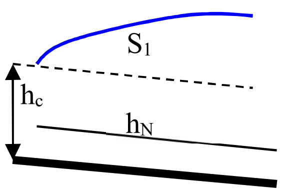
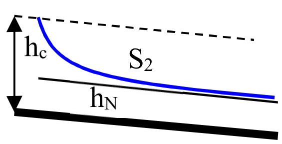
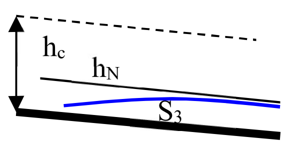
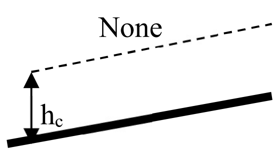
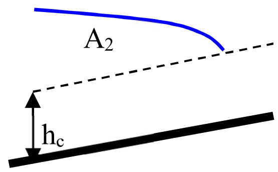
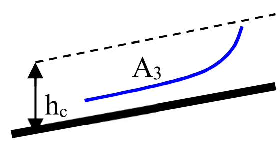
Change in reservoir volume: ΔV = Volume of I – Volume of Q

If the input I = 0, the change in time: $\Delta t = \frac{-As}{Q}\Delta h$

Time needed to empty reservoir of constant surface area through small orifice: $T = \frac{2As}{C_d a\sqrt{2g}}\left(H_1^{1/2} - H_2^{1/2}\right)$

Time needed to empty reservoir of constant surface area through weir: $T = \frac{2As}{(2/3)C_d b\sqrt{2g}}\left(\frac{1}{H_2^{1/2}} - \frac{1}{H_1^{1/2}}\right)$

Water surface profiles

	Zone1: **h** > h_c and h_N	**Zone2**: **h** between h_c and h_N	**Zone3**: **h** < h_c and h_N
Horizontal slope			
Mild slope			
Critical slope			
Steep slope			
Adverse slope			

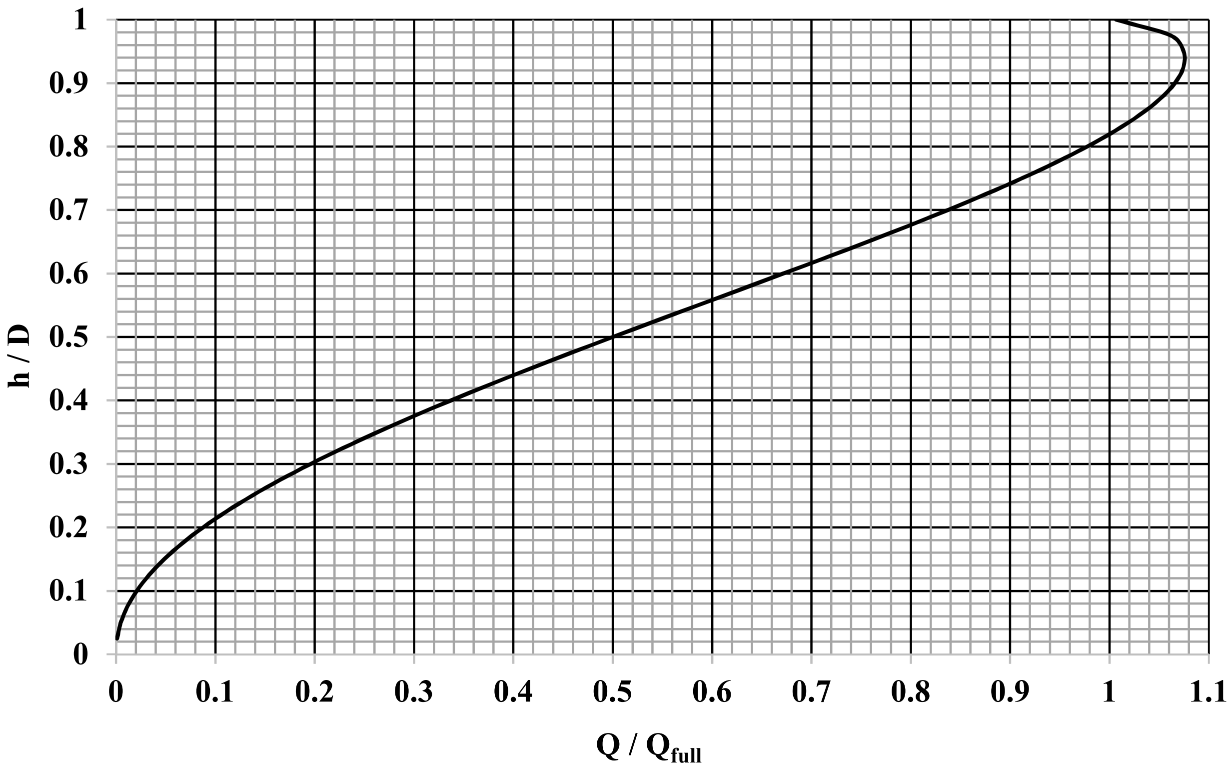


Fig. 1: Partial flow diagram for circular section.

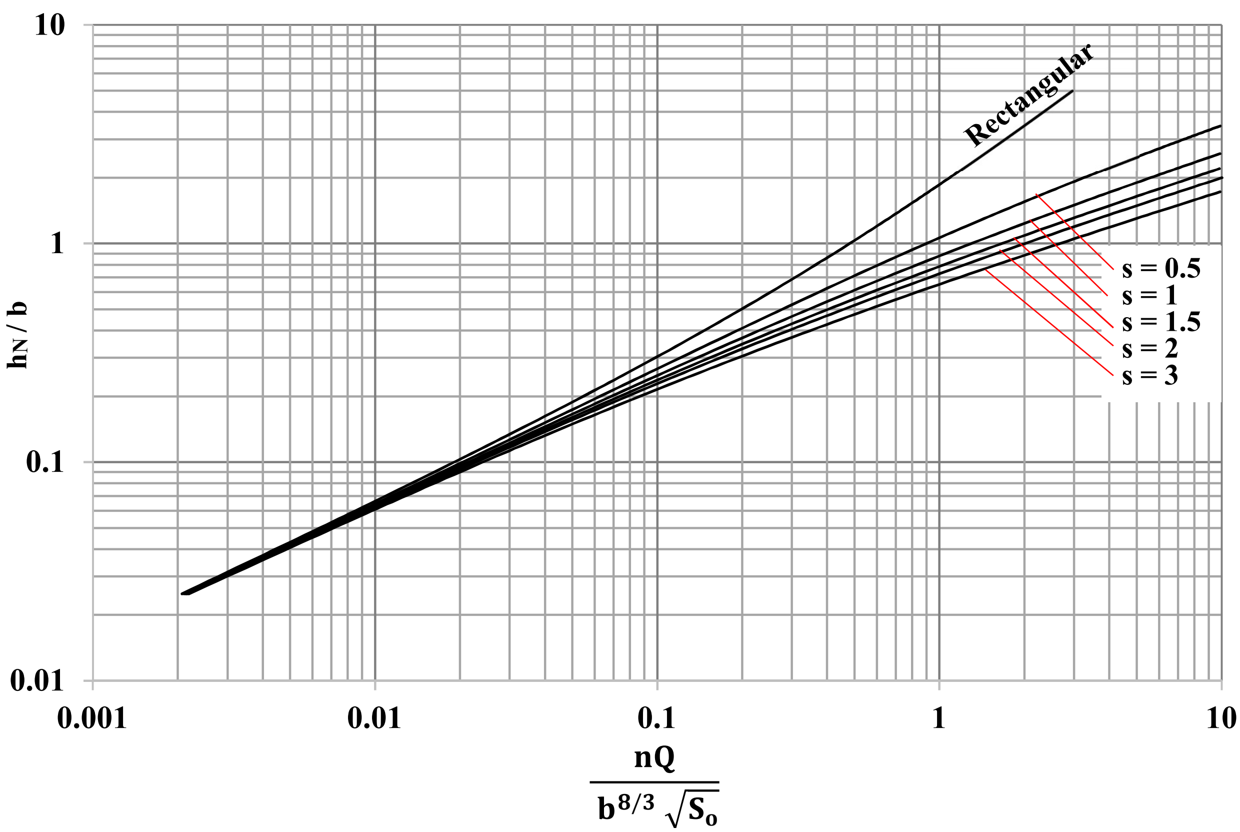


Fig. 2a: Normal depth for rectangular and trapezoidal sections.

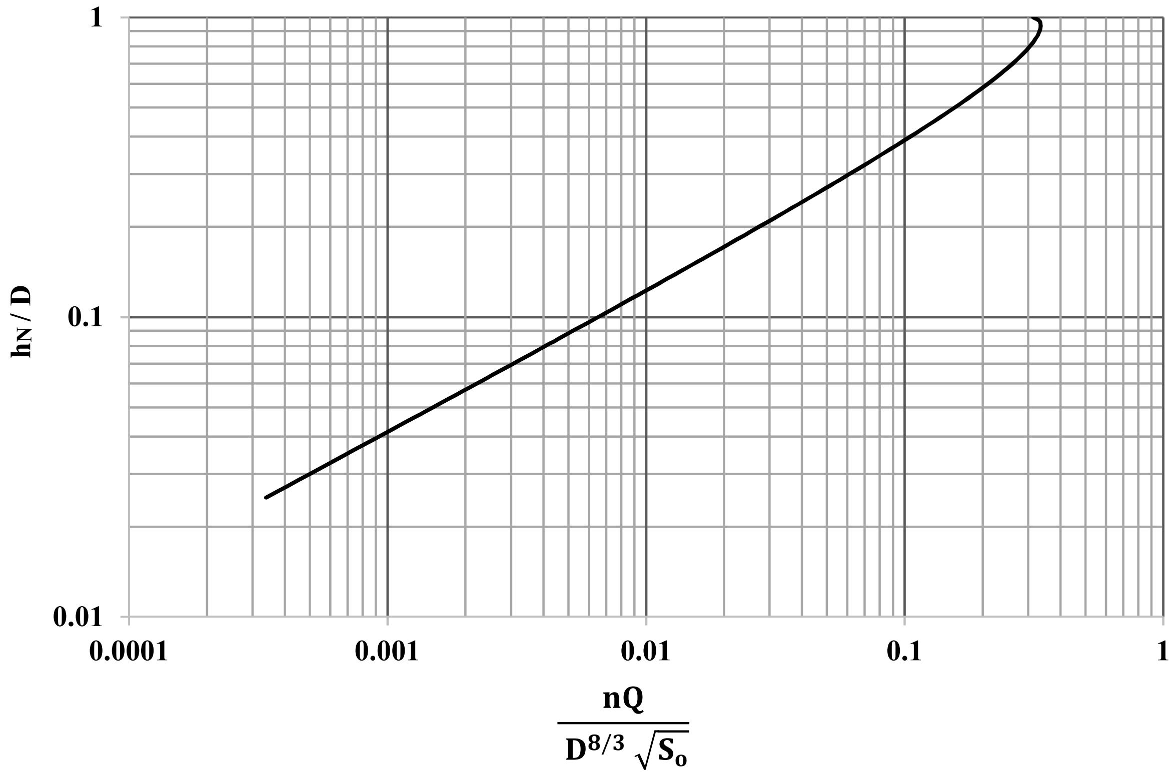


Fig. 2b: Normal depth for circular section.

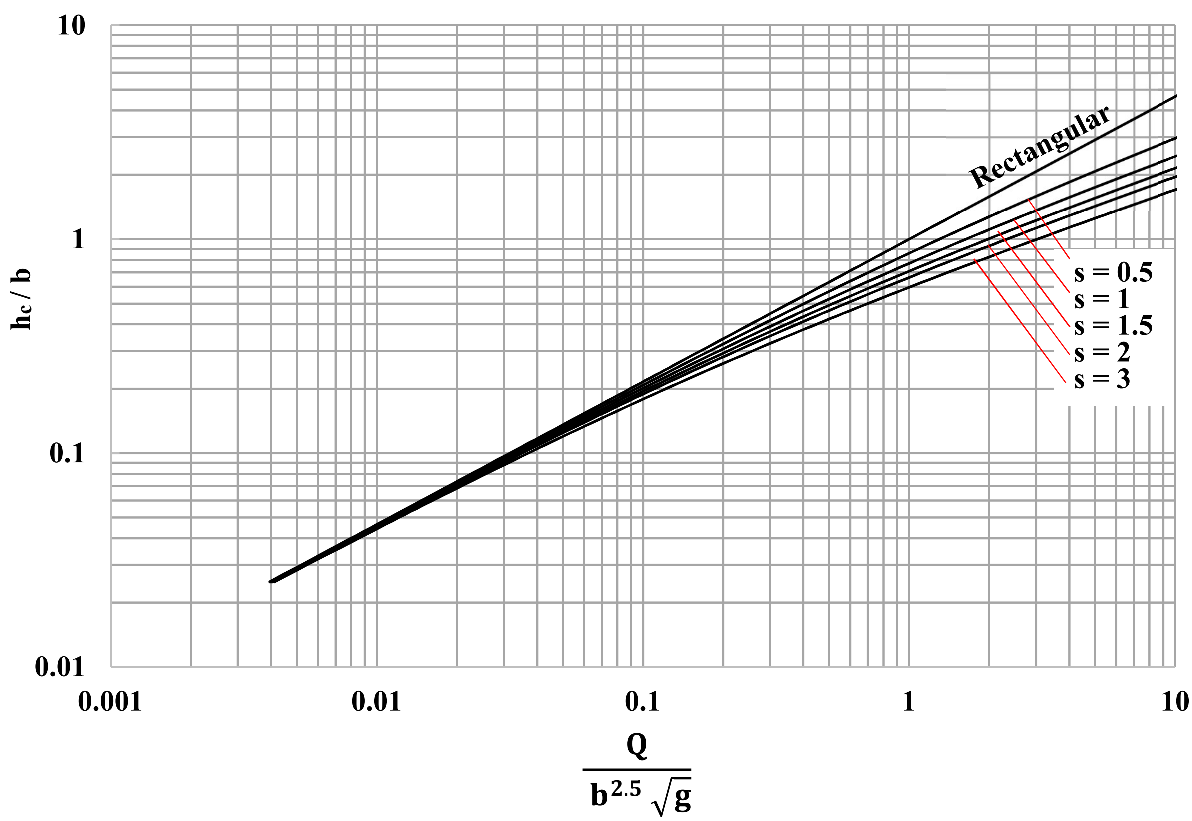


Fig. 3a: Critical depth for rectangular and trapezoidal sections.

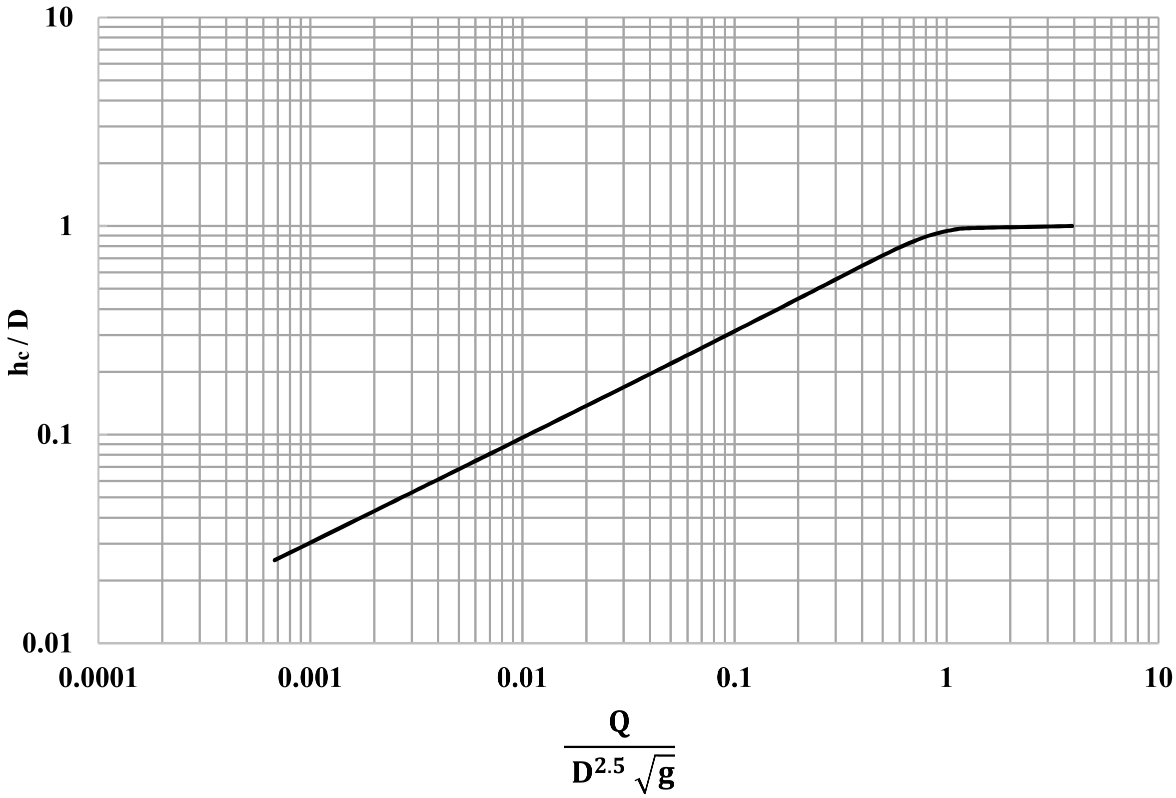


Fig. 3b: Critical depth for circular section.

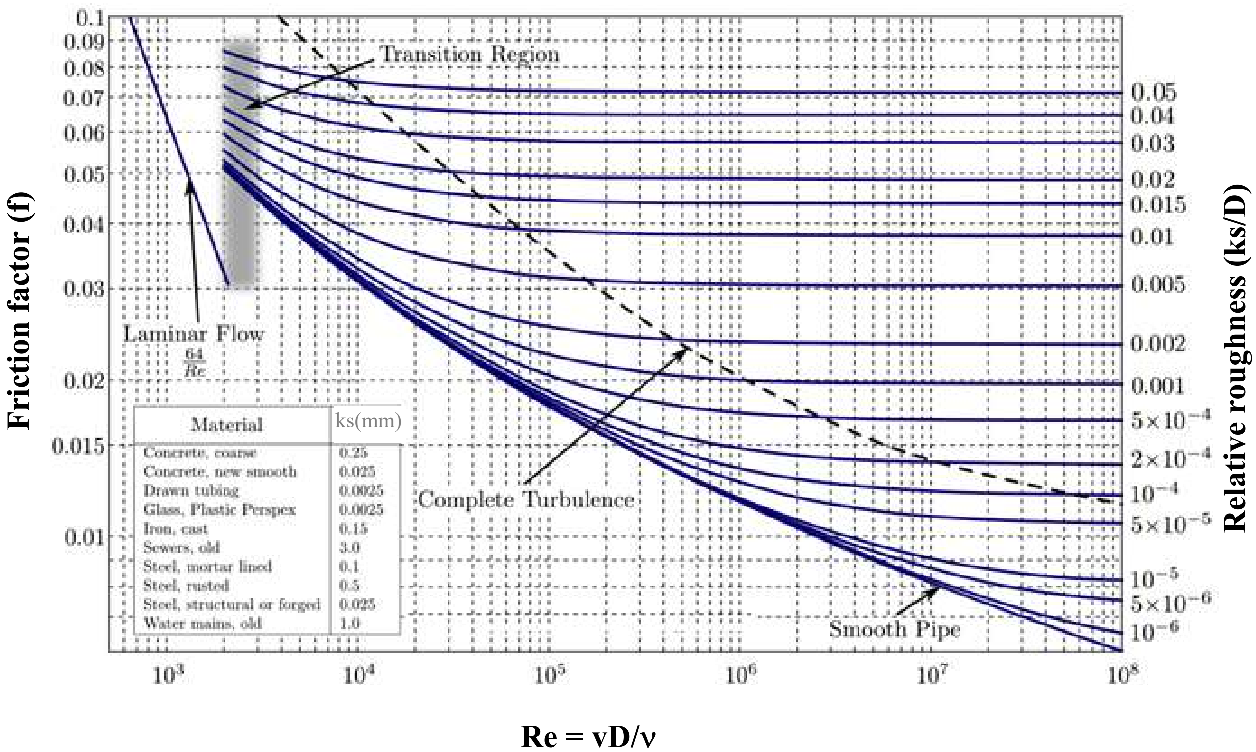


Fig.4: Moody diagram

Table1. Unlined channel: stable side slope

Material	Side Slope (Horizontal:Vertical)
Rock	Nearly Vertical
Muck and peat soils	$^{1}/_{4}$:1
Stiff clay or earth with concrete lining	$^{1}/_{2}$:1 to 1:1
Earth with stone lining or earth for large channels	1:1
Firm clay or earth for small ditches	$1^{1}/_{2}$:1
Loose, sandy earth	2:1 to 4:1
Sandy loam or porous clay	3:1

Table2. Unlined channel: max permissible velocity

Channel Material	V_{max} (m/sec)
Sand and Gravel	
Fine sand	0.6
Coarse sand	1.2
Fine gravel[a]	1.8
Earth	
Sandy silt	0.6
Silt clay	1.0
Clay	1.8