Solution (25pt each)

CE 313 2nd Midterm, Winter 2013

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Name: ______________________________ **Date:** 03/08/2013

- ✓ **The exam duration is 50 minutes. Exam is closed book, closed notes and open mind**
- ✓ **The exam is out of 100 points**
- ✓ **Justify your solutions as the procedure will be graded**
- ✓ **Only specified calculators in the syllabus will be permitted**
- ✓ **Use the exam sheets only for completing the exam unless authorized by the instructor**

1. A **rectangular channel** is flowing in "maximum hydraulic efficiency" conditions. If the channel is also flowing in critical **AND** normal flow conditions, **find the flow discharge**. The longitudinal slope of the channel is 0.003 and the Manning's roughness "*n*" is 0.015.

$y_c = y_n$ $\quad S_0 = 0.003$

$Q_n = Q_c$ $\quad n = 0.015$

$Q_n = Q_c$ $\quad Fr = 1 = V/\sqrt{gA/T}$

$\frac{1}{n} \cancel{A} R_h^{2/3} S^{1/2} = \cancel{A}\sqrt{gA/T}$

$\frac{1}{0.015}\left(yb/b+2y\right)^{2/3}(0.003)^{1/2} = \sqrt{gyb/b}$

$2y = b \Rightarrow 3.65(0.5y)^{2/3} = 3.13y^{1/2}$

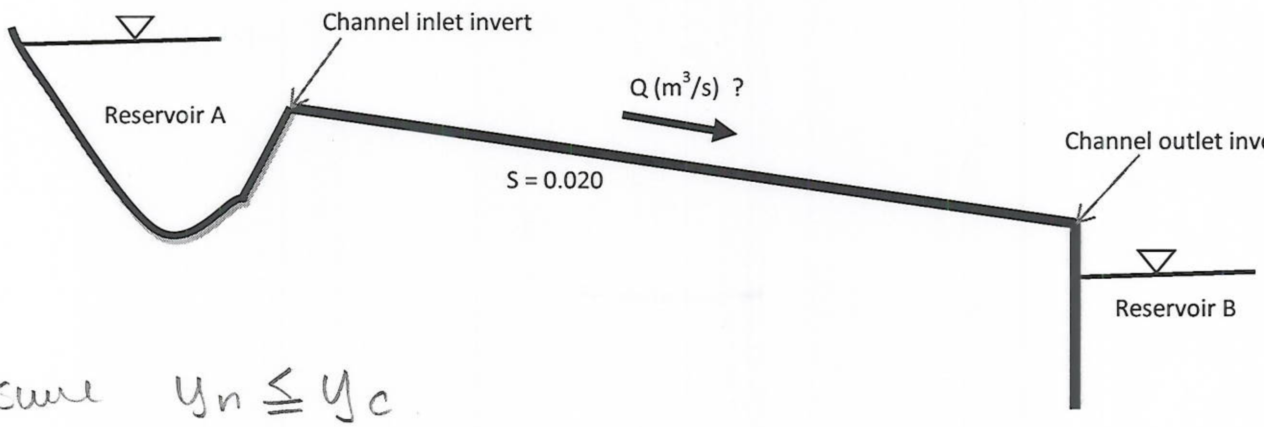
$y = 6.35\,m \quad b = 12.71\,m \leftarrow$ (or ft)

$Q = A\sqrt{gy} = (yb)\sqrt{gy} = (6.35 \times 12.71)\sqrt{9 \times 6.35}$

$= 637\ m^3/s \quad (g = 9.81\,m/s^2)$

or $= 1154.1\ ft^3/s \quad (g = 32.2\,ft^3/s)$

2. A **long** rectangular channel connects reservoirs "A" and "B" as sketched below. The channel has a width of 10 m, a longitudinal slope of 0.020 and a Manning's roughness "*n*" of 0.040. If the upstream reservoir water surface is 4.00m above the channel inlet invert and the downstream reservoir water surface is below the channel outlet invert, determine the flow discharge in the channel in m^3/s. Neglect local head losses.



Assume $y_n \leqq y_c$

Since $Fr = 1$ $\quad V_c = \sqrt{g y_c}$, $\quad V_c^2/2g + y_c = 4$

Solve for $y_c = 2/3\,H = 2.667\,m$

On the other hand, $\quad q = Q^*/b = \sqrt{g y_c^3} = 13.6\,m^2/s$

$$Q^* = q \times b = 136\,m^3/s = \frac{k}{n} A R_h^{2/3} S^{1/2}$$

Solving for y_n,

$$Q^* = \frac{1}{0.040}(y_n b)\left(\frac{y_n b}{y_n + 2b}\right)^{2/3}(0.020)^{1/2} = 136\,m^3/s$$

$$y_n = 2.667\,m \quad (= y_c = 2.667\,m)$$

$\therefore$ Assumption is correct $y_n \leq y_c$

Note that $y_n = y_c$, which means that the flow in this channel is critical and normal at the same time.

3. At a given location, under normal conditions a river flows with a Manning coefficient of **0.040**, and a cross section as indicated in Figure 10.61(a) [see below]. During flood conditions at this location, the river has a Manning coefficient of **0.060** and a cross section as shown in Figure 10.61(b). Determine the ratio of the flowrate during flood conditions to that during normal conditions.

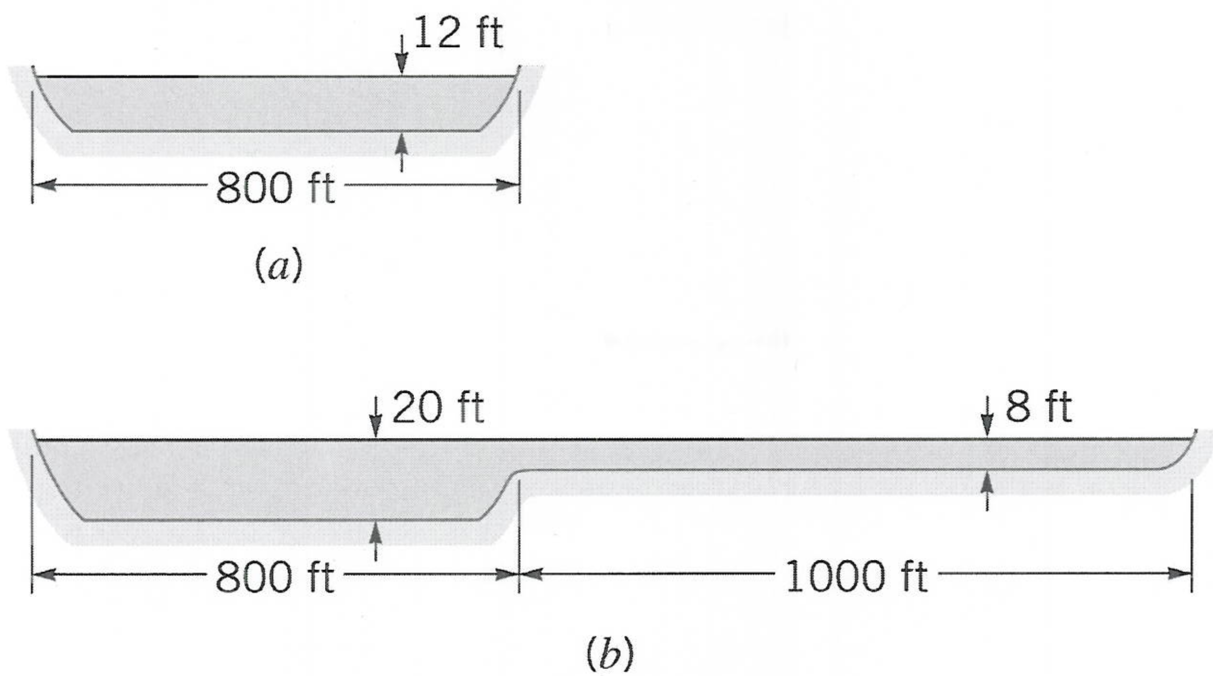


Figure P10.61

$$\frac{Q_b}{Q_a} = \frac{\frac{\cancel{k}}{n_b} A_b R_{hb}^{2/3} \cancel{S_{ob}^{1/2}}^{\,0}}{\frac{\cancel{k}}{n_a} A_a R_{ha}^{2/3} \cancel{S_{oa}^{1/2}}^{\,0}} = \frac{n_a A_b R_{hb}^{2/3}}{n_b A_a R_{ha}^{2/3}}$$

$A_b = 20 \times 800 + 8 \times 1000 = 24000\ ft^2$ $\quad R_{hb} = \frac{24000\ ft^2}{1800\ ft + 40\ ft} = 13.04\ ft$

$A_a = 12 \times 800 = 9600\ ft^2$ $\quad R_{ha} = 9600\ ft^2 / 824\ ft = 11.65\ ft$

$$Q_b / Q_a = \frac{0.040}{0.060} \left(\frac{24000\ ft^2}{9600\ ft^2}\right) \left(\frac{13.04\ ft}{11.65\ ft}\right)^{2/3}$$

$$= \frac{960}{576} (1.078) = 1.797$$

$$\boxed{Q_b / Q_a = 1.797}$$

4. The canal shown below is to be widened so that it can carry **three times** the amount of water. Determine the additional width, ***L***, required if all other parameters (i.e., flow depth, bottom slope, surface material, side slope) are to remain the same.

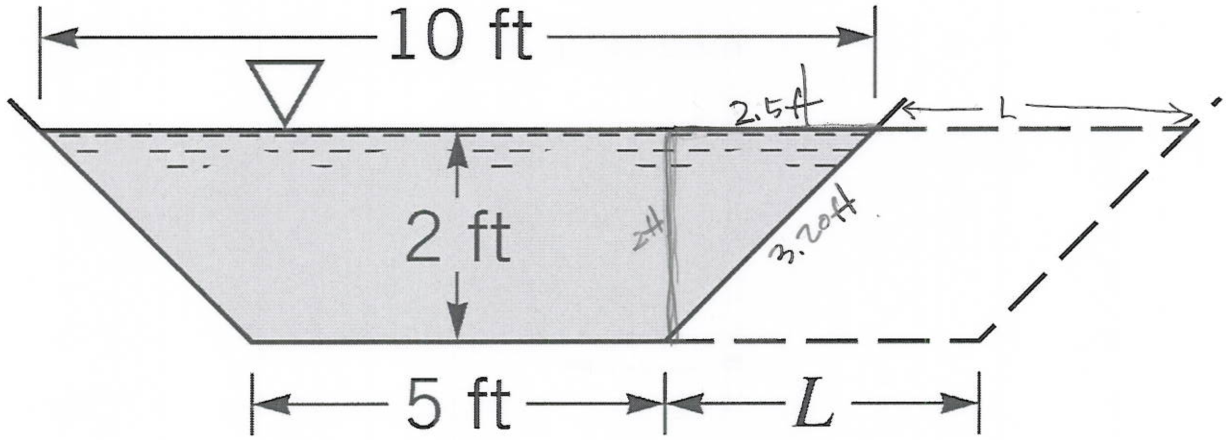


Figure P10.84

Let $()_o$ denote the original canal and $()_w$ the widened canal.

When $Q_w = 3Q_o$,

$$\frac{Q_w}{Q_o} = \frac{\cancel{k/n_w}\, A_w R_{hw}^{2/3}\, \cancel{S_{0w}}^{1/2}}{\cancel{k/n_o}\, A_o R_{ho}^{2/3}\, \cancel{S_{0w}}^{1/2}} = \frac{A_w R_{hw}^{2/3}}{A_o R_{ho}^{2/3}} = 3$$

While, $A_o = (10+5\text{ ft}) \times 2 \times 1/2 = 15\text{ ft}^2$.

$R_{ho} = 15\text{ ft}^2 / (5\text{ ft} + 6.40\text{ ft}) = 1.316\text{ ft}$

$A_w = (10+5+2L) \times 2 \times 1/2 = (15+2L)\text{ ft}^2$.

$R_{hw} = (15+2L) / (5+L+6.40) = (15+2L)/(11.4+L)$

Then,

$$(15+2L)\frac{(15+2L)^{2/3}}{(11.4+L)^{2/3}} = 3\left[15 \times 1.316^{2/3}\right]$$

$$= 54.03$$

$\Rightarrow \boxed{L \fallingdotseq 11.8\text{ ft}}$