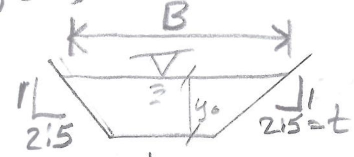
ENCE 4318

TEST 2

1. A trapezoidal channel is to be designed to carry a discharge of 250 cfs at a normal depth of 3.5 ft. The channel is running on a slope of 0.005 ft/ft and the side slopes can be no steeper than 2.5 H on 1 V. The channel is earthen and will have an estimated Manning n value of 0.03. What is the minimum bottom width to effect the required normal depth?

(pg 301)



$y_o = 3.5$ ft
$Q = 250$ cfs
$S = 0.005$ ft/ft
$t = 2.5$
$n = 0.03$

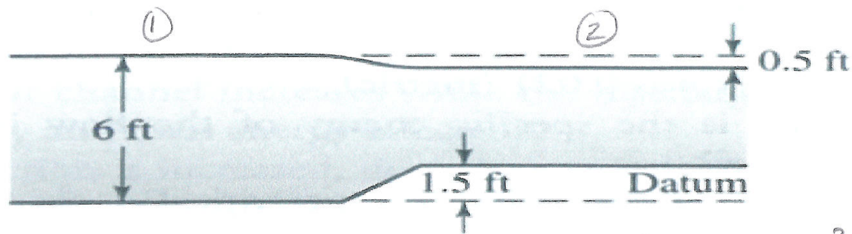
$$(b y_o + t y_o^2)\left[\frac{b y_o + t y_o^2}{b + 2 y_o (1+t^2)^{1/2}}\right]^{2/3} = \frac{0.03 \times 250}{\sqrt{0.005} \times 1.49}$$

$$\left[3.5b + (2.5 \times 3.5^2)\right]\left[\frac{3.5b + (2.5 \times 3.5^2)}{b + (2 \times 3.5)(1 + 2.5^2)^{1/2}}\right]^{2/3} = 71.19$$

$$\left[3.5b + 30.625\right]\left[\frac{3.5b + 30.625}{b + 18.848}\right]^{2/3} = 71.19$$

b = 4.21 ft

2. Water is flowing in a 10 ft wide rectangular channel at a depth of 6 ft. A 1.5 ft step-up in the channel bottom is encountered and the water level over the step (with reference to the upstream channel invert) drops by 0.5 ft as shown. Ignoring losses, what is the discharge in the channel?



$Q = A_1 V_1 = A_2 V_2$

$Q = (10 \times 6) V_1 = (10 \times (6-2)) V_2$

$Q = 60 V_1 = 40 V_2$

$\therefore V_2 = 1.5 V_1$

$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} + \Delta Z$ (assume $\alpha = 1$)

$6 + \frac{V_1^2}{2(32.2)} = 4 + \frac{(1.5 V_1)^2}{2(32.2)} + 1.5$

$0.5 + \frac{V_1^2}{64.4} = \frac{(1.5 V_1)^2}{64.4}$

$V_1 = 5.075$ ft/s

$Q = 60 V_1 = 60 \times 5.075$

$Q = 304.5$ cfs

3. The discharge through a 6.0 ft wide rectangular channel is 200.0 ft³/s. Find the conjugate depths of the jump formed in such a channel if 3.5 ft of energy head is lost through it.

$$q = \frac{Q}{width} = \frac{200 ft^3/s}{6 ft} = 33.33 ft^3/s/ft$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{33.33^2}{32.2}\right)^{1/3} = 3.255 ft$$

[pg 412] $$y_1 = \frac{y_2}{2}\left[-1 + \sqrt{1 + 8\left(\frac{y_c}{y_2}\right)^3}\right]$$

[13.28] $$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$$

$$3.5 = \frac{\left[y_2 - \left(\frac{y_2}{2}\left[-1 + \sqrt{1 + 8\left(\frac{3.255}{y}\right)^3}\right]\right)\right]^3}{4 y_2\left(\frac{y_2}{2}\left[-1 + \sqrt{1 + 8\left(\frac{3.255}{y}\right)^3}\right]\right)}$$

$$\boxed{y_2 = 6.38 \text{ ft}}$$

$$y_1 = \frac{6.38}{2}\left[-1 + \sqrt{1 + 8\left(\frac{3.255}{6.38}\right)^3}\right]$$

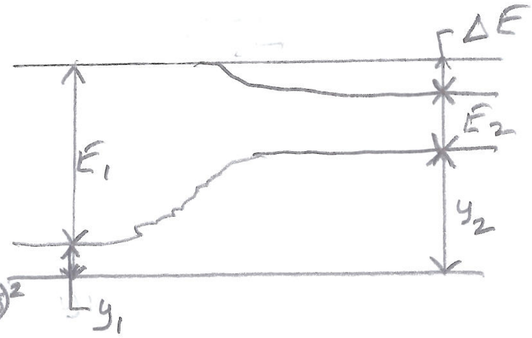
$$\boxed{y_1 = 1.39 \text{ ft}}$$

Check these out

$$\Delta E = E_1 - E_2$$

[12.12] $$\Delta E = \left[y_1 + \frac{q^2}{2 g y_1^2}\right] - \left[y_2 + \frac{q^2}{2 g y_2^2}\right]$$

$$3.5 = \left[1.39 + \frac{(33.33)^2}{2(32.2)(1.39)^2}\right] - \left[6.38 + \frac{33.33^2}{2(32.2)(6.38)^2}\right]$$



$$3.5 = 10.318 - 6.804$$

$$3.5 = 3.514$$

Very Close OK

4. A 12.0 m rectangular channel, having a bed slope of 50 cm/km and a Manning roughness coefficient of 0.015, conveys water at a normal depth of 1.0 m. A dam is built across the channel at which the water depth is 2.0 m. Calculate the depth of flow 2.0 km upstream of the dam.

Direct Step Method

$S_{o\,(bed)} = 50\,cm/km = 0.0005\ km/km$

$n = 0.015$

$b = 12m$

$d_1 = 2m$

$d_n = 1m$

$A = b \times d_n = 12 \times 1 = 12m^2$

$P_w = (2 \times d) + b = (2 \times 1) + 12 = 14m$

$R_h = \frac{d \times b}{b + (2 \times d)} = \frac{12 \times 1}{12 + (2 \times 1)} = \frac{12}{14} = 0.857$

$Q = \frac{1}{n} A R_h^{2/3} S^{1/2} = \frac{1}{0.015} \times 12m^2 \times 0.857^{2/3} \times 0.0005^{1/2} = 16.14\ m^3/s$

$q = \frac{1}{n} d^{5/3} S^{1/2} = \frac{1^{5/3}}{.015}(0.0005)^{1/2} = 1.491\ m^3/s/m$

$V_1 = \frac{Q}{A_1} = \frac{16.14}{12} = 1.345\ m/s$

$d_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{1.491^2}{9.8}\right)^{1/3} = 0.610\ m$

since $d_n > d_c$ Channel has a mild Slope & flow is subcritical

From HEC-RAS $V_2 = 0.8861\ m/s$

$S_f = \left(\frac{nq}{d_n^{5/3}}\right)^2 = \left(\frac{0.015 \times 1.345}{1}\right)^2$

$S_f = 0.0004$

$\Delta x = \frac{\Delta d - \frac{\Delta V^2}{2g}}{S_f - S_o}$

$2000m = \frac{(2m - d_2) - \frac{(1.345 - 0.8861)^2}{64.4}}{0.000407 - 0.0005}$

$2000 = \frac{(2m - d_2) - 0.21059}{-0.000093}$

$-0.186 = (2m - d_2) - 0.21059$

$2m - d_2 = 0.02459$

$-d_2 = -1.98m$

$d_2 = 1.98\ m$

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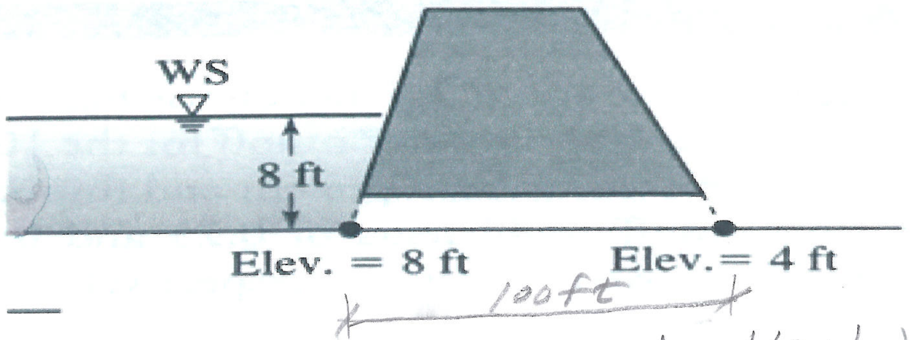
Data Below from HEC-RAS for Test Problem #4

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	E.G. Elev (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
A	2000	PF 1	16.14	0	1.5179	1.5579	0.8861	18.2146	12	0.2296
A	1500.*	PF 1	16.14	0	1.4388	1.4833	0.9348	17.2654	12	0.2488
A	1000.*	PF 1	16.14	0	1.342	1.3931	1.0023	16.1036	12	0.2762
A	500.*	PF 1	16.14	0	1.2133	1.2759	1.1086	14.5594	12	0.3213
A	0	PF 1	16.14	0	0.9999	1.0921	1.3451	11.9989	12	0.4294

5. An embankment is traversed by a 6 ft x 6 ft concrete box culvert 100 ft long. The upstream invert is at an elevation of 8 ft and the downstream invert 4 ft. If the depth at the upstream end of the culvert is 8 ft, what is the flow through the culvert? Assume the culvert is in inlet control.



See Culvert Master output attached

Assuming:

Mannings n = 0.013 (concrete)

Entrance = 90° headwall w/45° bevels

ke = 0.20

Q = 363.42 cfs

V = 21.17 f/s

depth = 2.86 ft

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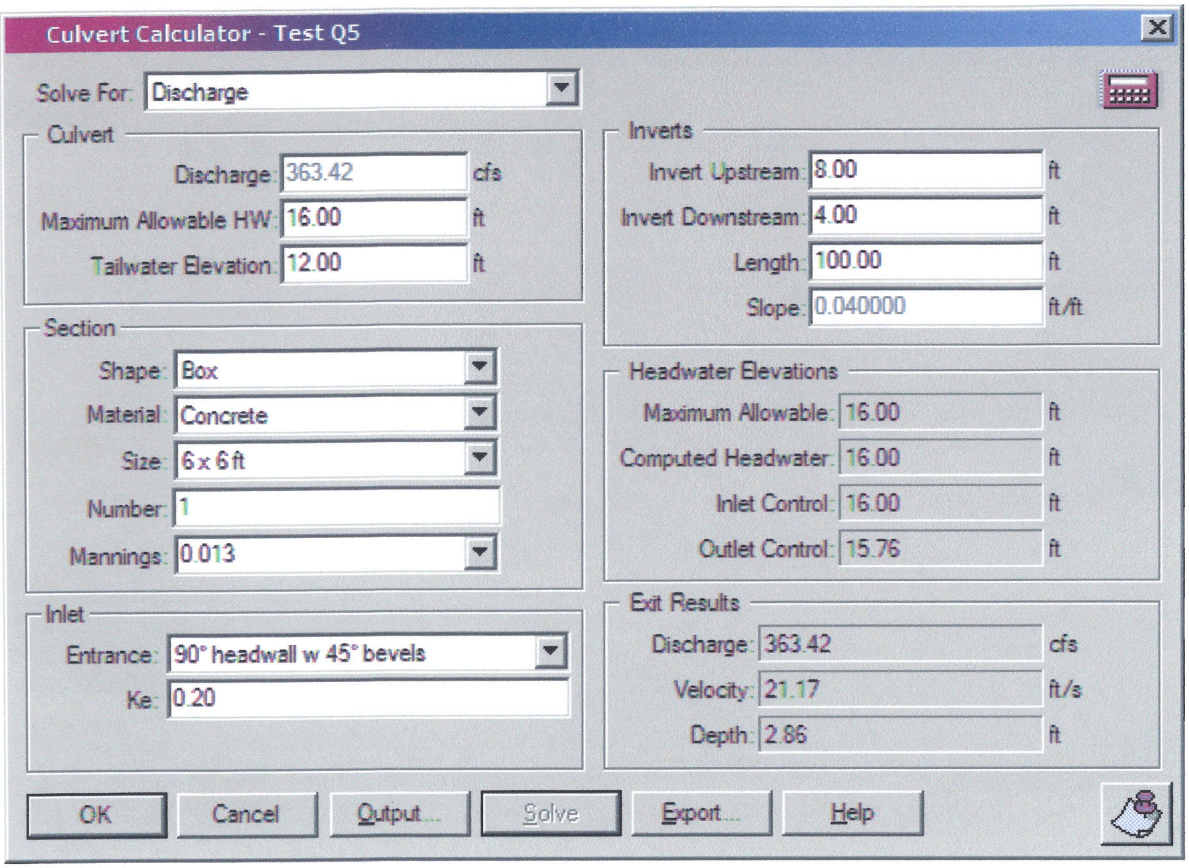

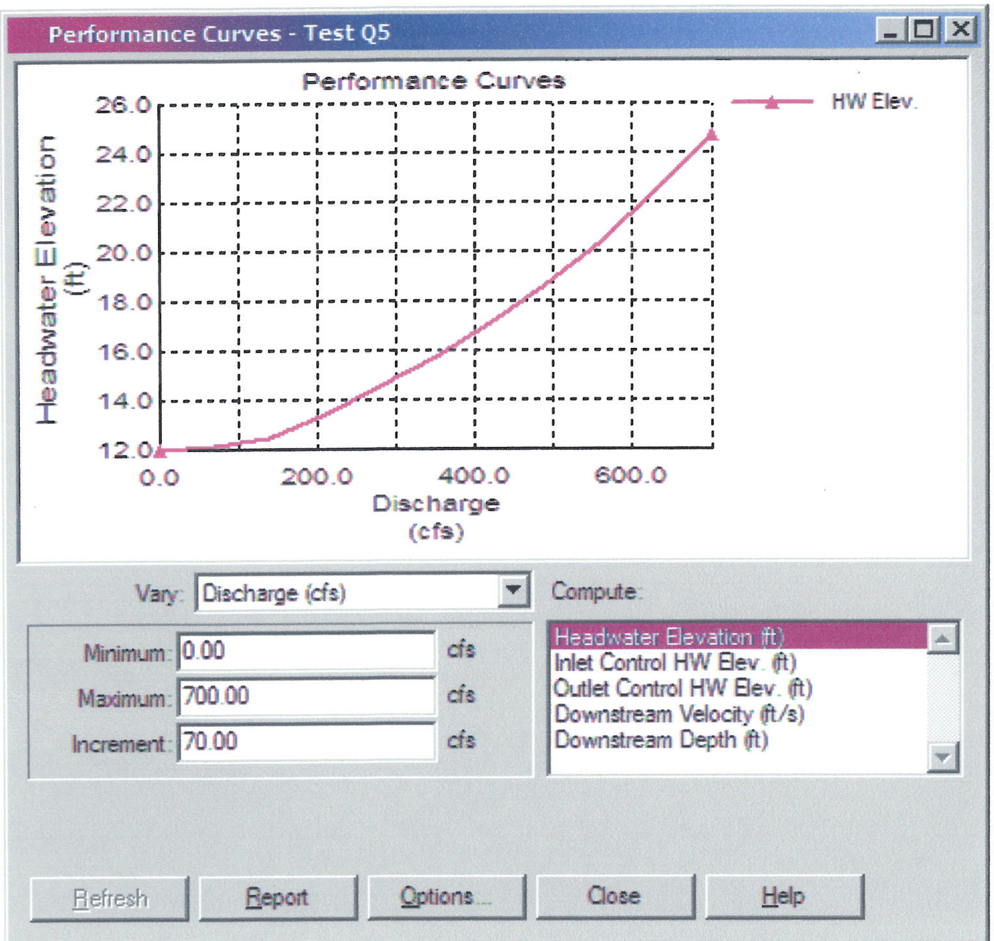
Performance Curves - Test Q5
Performance Curves
HW Elev.
Headwater Elevation (ft)
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
0.0
200.0
400.0
600.0
Discharge (cfs)
Vary: Discharge (cfs)
Compute:
Minimum: 0.00 cfs
Maximum: 700.00 cfs
Increment: 70.00 cfs
Headwater Elevation (ft)
Inlet Control HW Elev. (ft)
Outlet Control HW Elev. (ft)
Downstream Velocity (ft/s)
Downstream Depth (ft)
Refresh
Report
Options...
Close
Help