

MEMORANDUM

To:	P. N Guin
From:	P. Olar Bear
Date:	04MAR2024
Subject:	CE 3372 – Water Systems Design, Exercise Set 18.

Purpose

The purpose of the exercise is to develop expertise in application of gradually varied flow equation in open channel flow, and practice Excel skills for simple geometries. The exercise is repeated in SWMM in the next exercise.

Discussion

The solution is presented below after re-statement of the problem. Relevant discussion components are imbedded within the solution.

Problem Statement

1. Water flows at a steady rate of $192 \text{ ft}^3/\text{s}$ through a concrete-lined rectangular channel 16 ft wide as depicted in Figure 1. The water enters the 0.35% sloped channel ($S_0 = 0.0035$) at location 1 and is flowing at 110% normal depth ($1.1 \times y_n$). The water exits over a 3-foot tall weir (assume sharp-crest weir) at location 2.¹

Determine:

- i The critical depth for the channel (in feet).
- ii Assuming flow over the weir must pass through critical depth, what is the pool depth just upstream of the weir? (Hint: Add the critical depth to the weir height as an approximation to the pool depth)
- iii Using the variable-step method, determine the water-surface profile from location 1 to location 2.

¹The water-surface-profile spreadsheet on the class server can be adapted to this problem, or you can create your own.

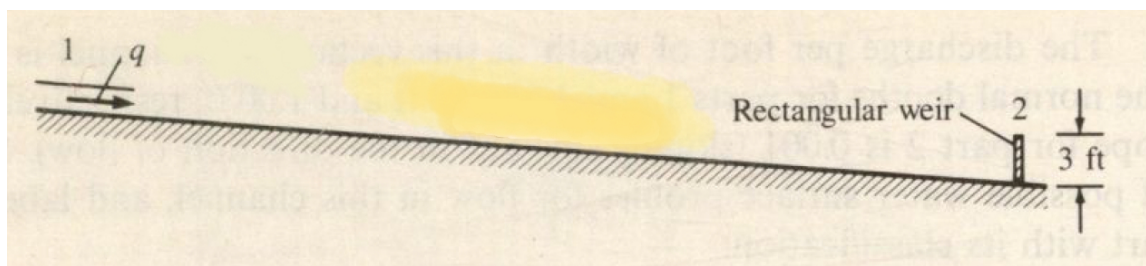


Figure 1: Profile of concrete-lined rectangular channel.

- iv How far upstream from the weir is the flow at 110% normal depth? (i.e. how far upstream is location 1 from location 2).
- v What is the average Δx in your computations if the Δy is 0.1 feet?
- vi Include sample calculations (if you use a spreadsheet, screen capture a portion of the calculations section).
- vii Include a plot of the water surface elevation, and the channel bottom elevation (a profile plot – like the figure, but with the horizontal distance as the x-axis).

Solution

To address the specific questions the following steps are required:

- (a) Build a tool to take Q , n , Width as input. Figure 2 is such a tool with these inputs along the left side of the spreadsheet.
- (b) Compute normal and critical depth for the channel. Normal depth is computed using Manning's equation for a rectangular channel, then apply goal seek until the computed flow rate agrees with the prescribed flow rate. For the supplied problem values the normal depth is about 1.509 feet. Critical depth is computed setting the Froude number for the rectangular channel to unity (one) and solving for the required flow depth. For the supplied problem values the critical depth is about 1.648 feet.
- (c) Assume depth at weir is weir height+critical depth – use that as starting value for the numerical method. For the supplied problem values, the pool depth just upstream of the weir is about 4.648 feet.
- (d) Use variable step method as outlined in class and compute spacing as depth is changed. For the supplied values, we start at the weir and compute upstream, using depth increments of 0.1 feet until the depth is at 110% of normal depth,

which for this problem is about 1.66 feet.

(e) Plot the results.

Implementing these steps is shown in Figure 2 and Figure 3. Figure 3 is the graphics portion of the spreadsheet that displays the plot.

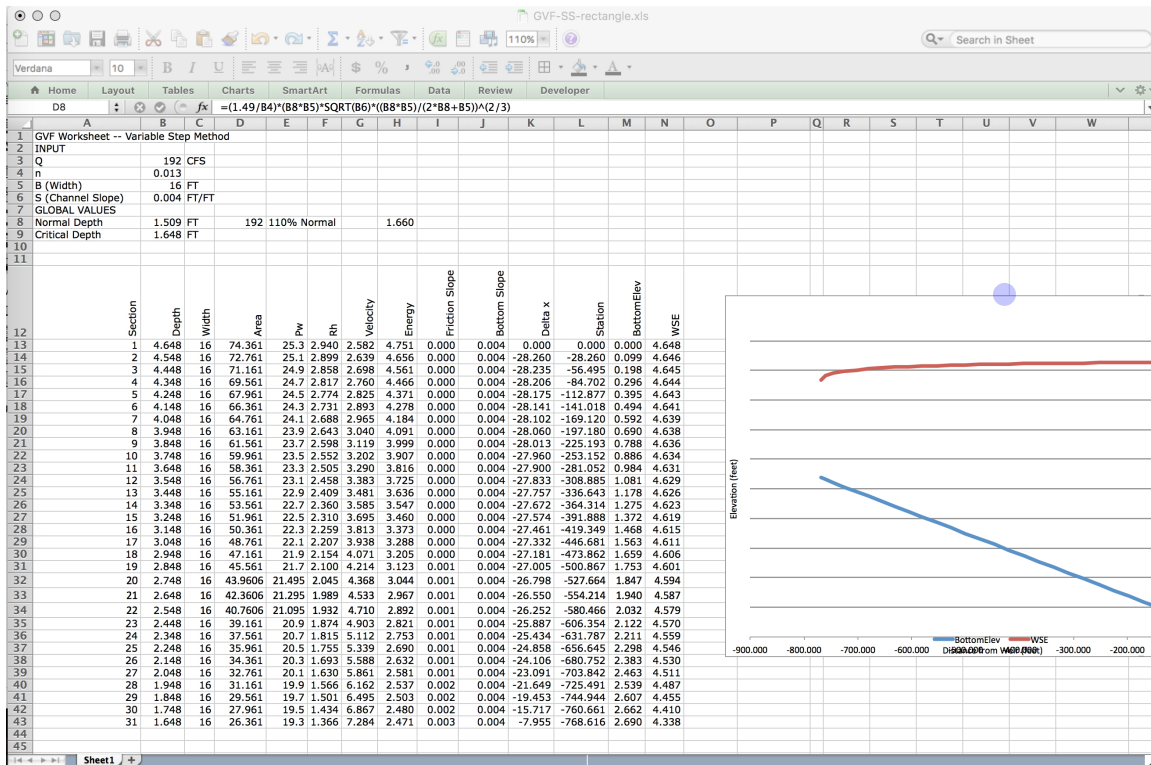


Figure 2: GVF Spreadsheet for channel in Figure 1

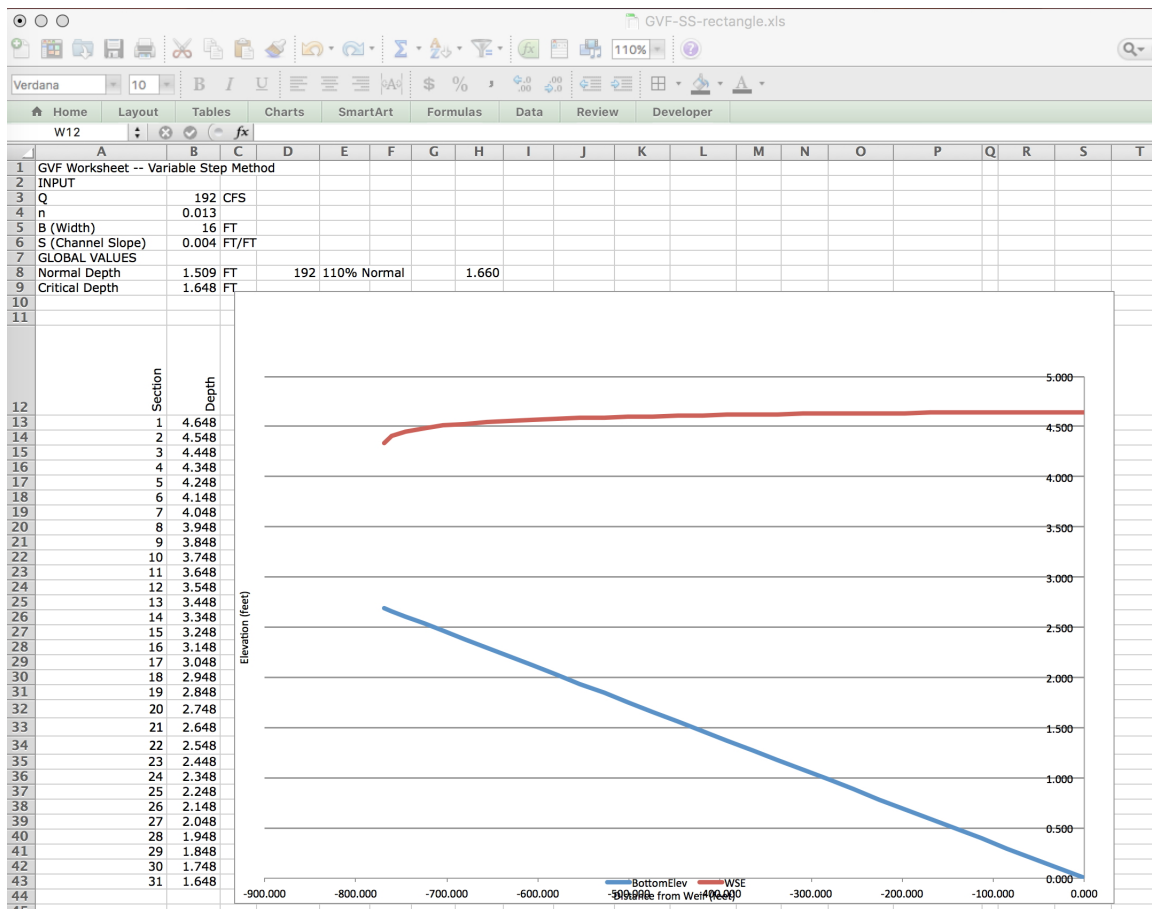


Figure 3: GVF Spreadsheet for channel in Figure1

The average spacing can be estimated as the total distance $\approx 768\text{ft.}$ divided by the number of reaches (in this solution 30), which is $\approx 25.6\text{ft.}$ Use this value in the next exercise where the same problem is examined using SWMM.