Experiment Name: Steady Flow Modeling - Modeling Water Surface Profile with a Sinusoidal Bed

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Objectives

The objectives of this session are:

1. To generate a sinusoidal bed profile using given information
2. View and present the analyzed results

Given Data

- The channel is rectangular.
- The channel width is 100 m.
- The channel length is 3750 m.
- Use 50 m interval
- Manning's n can be assumed as $0.025\ s/m^{1/3}$.
- The discharge on the channel is $20\ m^3/s$.
- $Bed\ profile = Amplitude * cos(PI * distance/625)$
- $Amplitude = (Last\ two\ digits\ of\ your\ student\ number + 50)/100.$
- $Downstream\ boundary\ condition = (Amplitude + 0.3)\ m$
- $Student\ ID = 202330044$

Questions

1. Calculation of Longitudinal Bed Profile

Determination of amplitude:

$$A = \frac{44 + 50}{100}$$

$$\Rightarrow A = 0.94$$

Equation for longitudinal bed profile:

$$y = A\cos(\frac{\pi x}{625})$$

$$\Rightarrow y = 0.94\cos(\frac{\pi x}{625})$$

Sample Calculations

- At RS 100 (x = 3750 m):

$$y = 0.94\cos\left(\frac{\pi \times 3750}{625}\right)\ \text{m}$$

$$\Rightarrow y = 0.940\ \text{m}$$

- At RS 99 (x = 3700 m):

$$y = 0.94\cos\left(\frac{\pi \times 3700}{625}\right)\ \text{m}$$

$$\Rightarrow y = 0.910\ \text{m}$$

2. Calculation of Downstream Boundary Condition

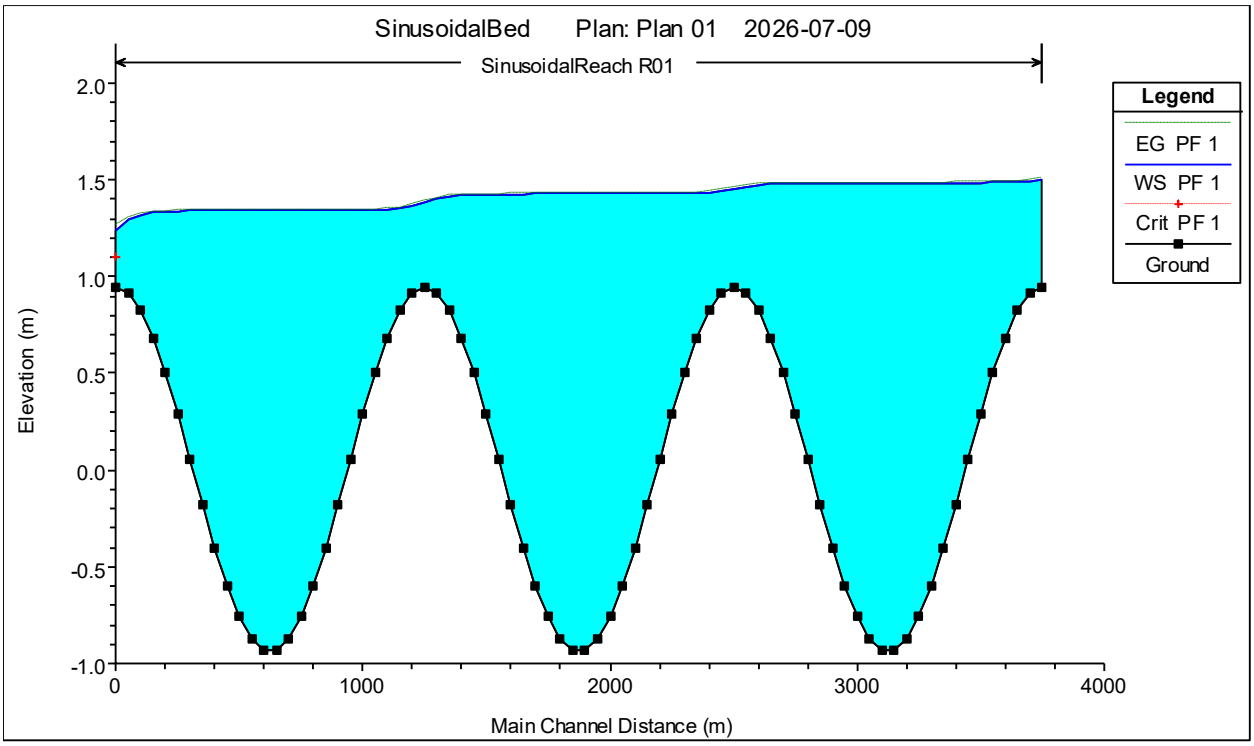
Downstream boundary condition is (Amplitude+0.3) m:

$$\text{Downstream W. S. Elev} = \text{A} + 0.3\ \text{m}$$

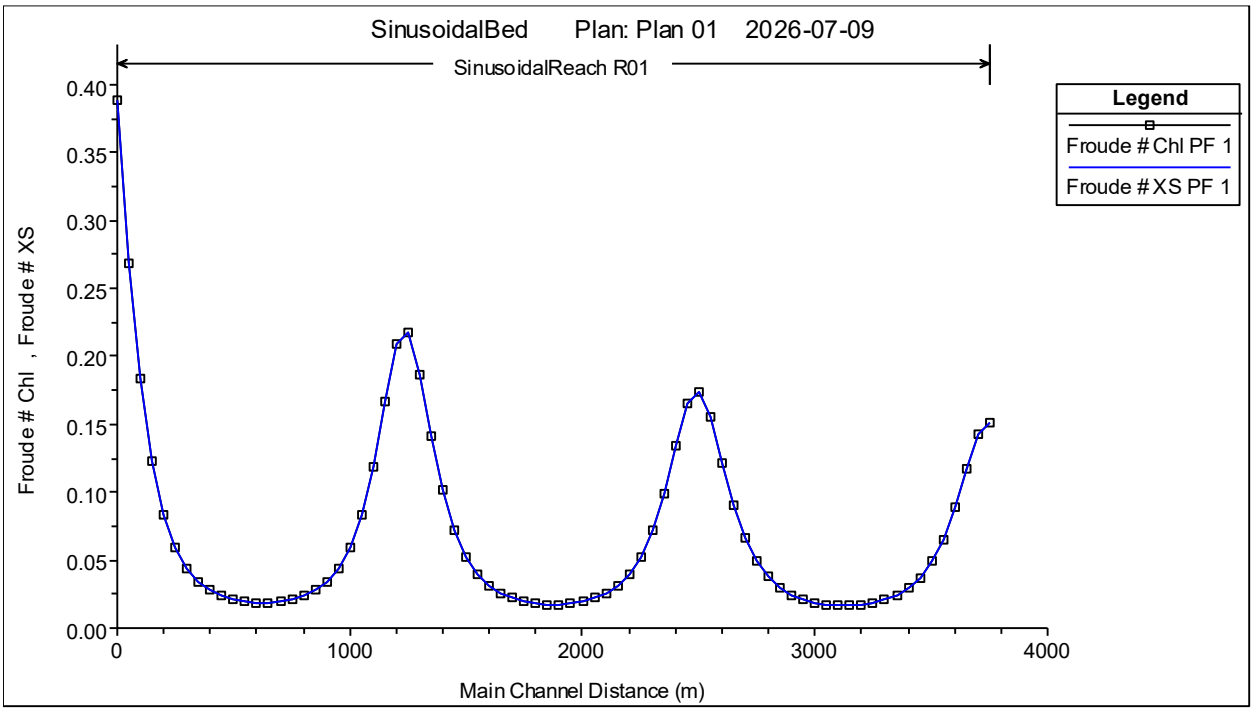
$$\Rightarrow \text{Downstream W. S. Elev} = 0.94 + 0.3\ \text{m}$$

$$\Rightarrow \text{Downstream W. S. Elev} = 1.24\ \text{m}$$

3. Longitudinal Profile of Water Surface Elevation



4. Longitudinal Profile of Froude Number



5. Does the Water Surface Elevation is out of Phase with Bed Elevation Profile

Yes, the water surface elevation is out of phase with bed elevation.

Justification:

- By observing the longitudinal profile of water surface elevation graph and summary output table by profile, it is found that where bed elevation reaches a peak of 0.94 m (e.g., RS 100, 75, 50, 25), the total depth of water reduces to its minimum value (e.g., for RS 75, 1.45 – 0.94 = 0.51 m).
- On the other hand, where bed elevation drops to a minimum of -0.93 m (e.g., RS 88, 87, 63, 62, 39, 38), the water depth increases to its maximum value (e.g., for RS 63, $1.43 - (-0.93) = 2.36$ m).
- This reduction of depth when bed elevation is highest and increase of depth when bed elevation is lowest confirms that the water surface profile operates out of phase with the underlying bed geometry.
- This happens because for a steady subcritical flow, the flow must decrease in depth over bed humps and increase in depth elsewhere.

6. What is a bar/island? How does a bar/island differ from other bed forms?

A bar is a large sediment deposit formed within a river channel due to erosion and deposition processes. When a bar becomes sufficiently elevated and remains exposed above the water surface for extended periods, it is commonly referred to as an island.

Difference:

Bars/Islands	**Other Bed Forms: Ripples/Dunes**
Large-scale bed forms	Small-scale bed forms
Form due to channel-scale sediment deposition	Form due to local sediment transport
May emerge above the water surface	Usually remain submerged
Long wavelength	Short wavelength
Rapidly change with flow conditions	Comparatively stable

7. Discussions

This laboratory demonstrated the practical application of HEC-RAS for steady gradually varied flow analysis over a sinusoidal channel bed. The sinusoidal bed generated in Excel successfully represented periodic bed undulations, enabling the investigation of flow behavior over varying bed elevations.

The results showed that the flow remained subcritical throughout the reach, as indicated by Froude numbers below unity. Consequently, the computed water surface profile remained out of phase with the bed profile, consistent with the expected theoretical hydraulic behavior of for the reach.

The exercise also illustrated the importance of defining accurate channel geometry and appropriate downstream boundary conditions in numerical river modelling. Overall, the laboratory enhanced understanding of gradually varied flow theory and provided practical experience in developing, executing, and interpreting HEC-RAS simulations.