Hydraulic Engineering and Infrastructures

Civil Engineering Department

Flow profiles

1 Sea Level Variation

A very wide river that discharges its waters into the sea has a discharge per unit width of $q = 5\ \mathrm{m}^2/\mathrm{s}$, a bed slope of $i = 0.0005$, and a roughness coefficient of $n = 0.03$.

As shown in Figure 1, after the river mouth it can be assumed that the seabed has an 8% slope. The tidal level may vary from elevation $+0.5$ m up to $+4.5$ m. Determine the normal and critical depths in the river before the mouth, and perform a qualitative analysis of the hydraulic profile in the river under the extreme tidal conditions.

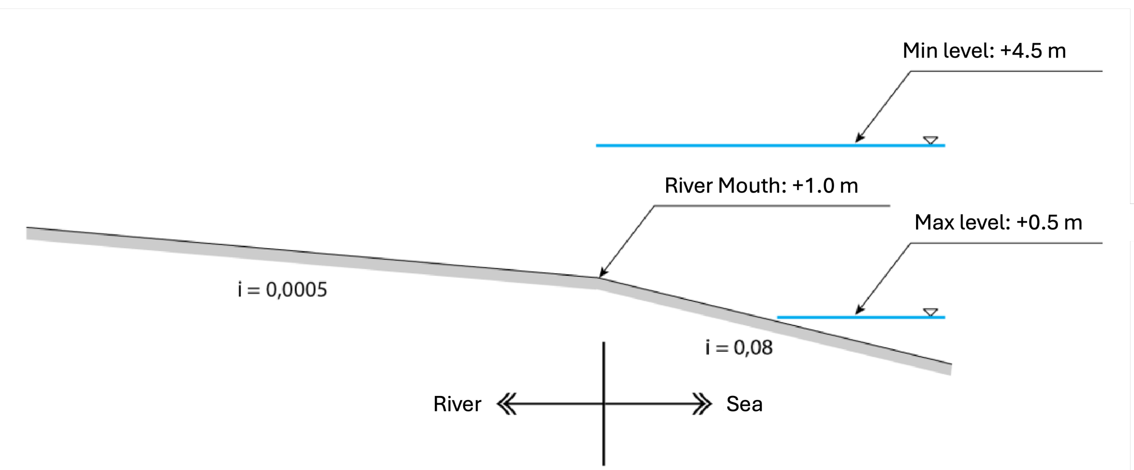


Figure 1: Schematic representation of the river–sea system.

Recommended procedure

1. Compute y_c via the Froude number and y_n via the Chézy or Manning equation.

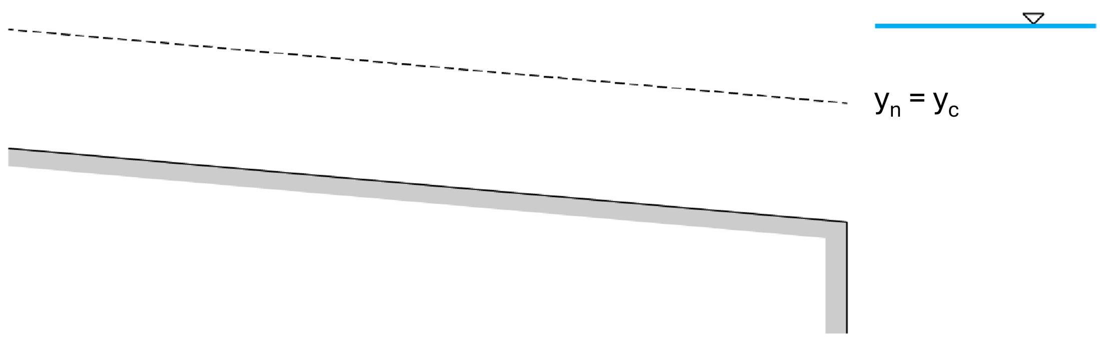
2. Determine the control point(s) (CP) which correspond to where the regime changes (eg. change of slope). When drawing the qualitative profiles, each CP will be the starting point.

3. Determine the direction in which the drawing will be done, starting from the CP.
   If $y > y_c$, the flow is subcritical meaning that you move upstream from the CP.
   If $y < y_c$, the flow is supercritical meaning that you move downstream from the CP.

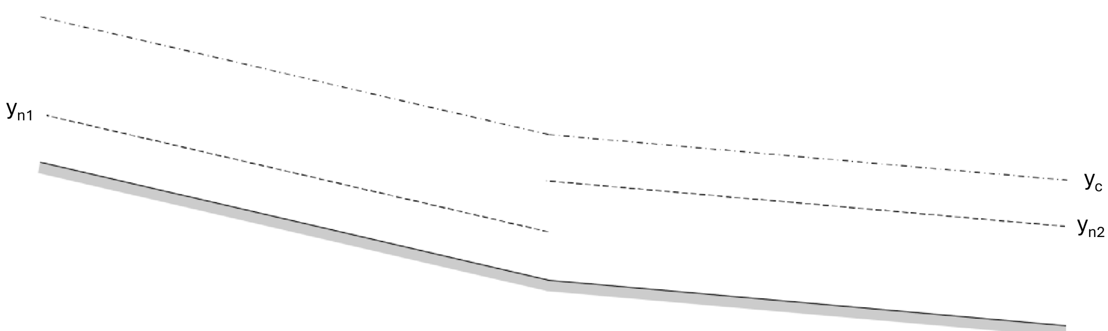
2 Qualitative Profiles

In the following cases, perform a qualitative analysis of the water-surface profile (hydraulic grade line), identifying the classification (type), control points, and starting points together with their computation direction. Draw your sketches on the diagrams provided below.

(a)



(b)



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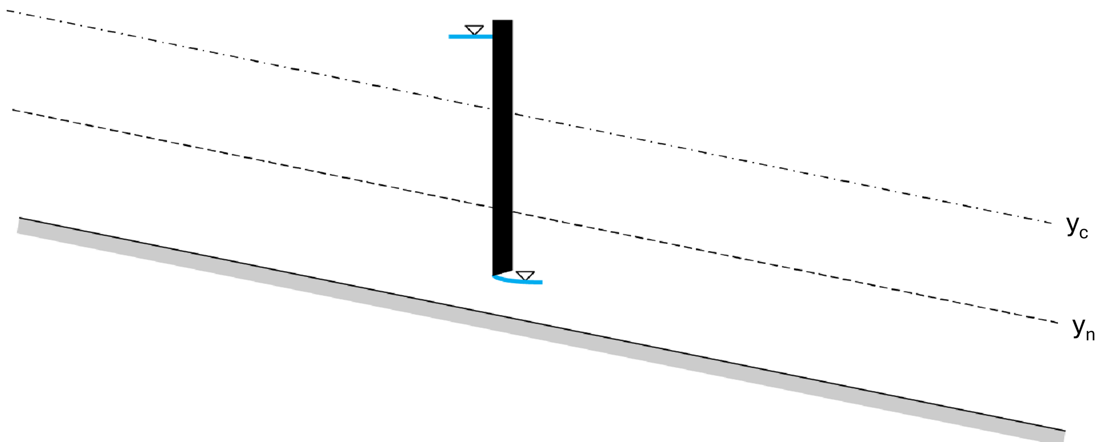

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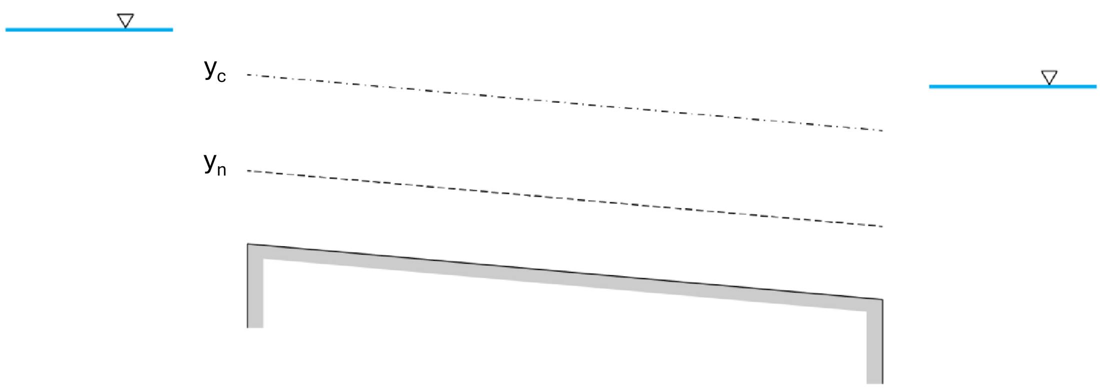

3 Spillway into stilling basin

The spillway of a reservoir has an approach channel with a trapezoidal cross-section with a (base of $10\,\mathrm{m}$, side slopes of 1/1 (H/V)) that ends in a weir of height $a = 2\,\mathrm{m}$.

There is a spillway with a rectangular cross-section after the weir with same width of 10 m, dropping 20 m and ending in a stilling basin where a hydraulic jump is supposed to form.

Downstream of the basin, a step of 4 m discharges the water into a river with a steep slope.

a) Draw the profile qualitatively, noting the supercritical or subcritical states. What happens when step's height c is small? What happens when it is big? Where are the main head losses?

b) Compute the discharge when the water depth y_1 in the approaching channel is of 5 m.

c) Estimate the water depth y_2 above the weir and the corresponding Froude number.

d) Assuming regular losses along the spillway are small, compute the water depth y_3 at the end of the spillway and the corresponding Froude number.

e) From now on, we assume the step is big. Compute the water depth y_4 after the hydraulic jump.

f) What should be the water depth y_5 over the step? Estimate the value of the necessary step height c to force a hydraulic jump in the stilling basin.

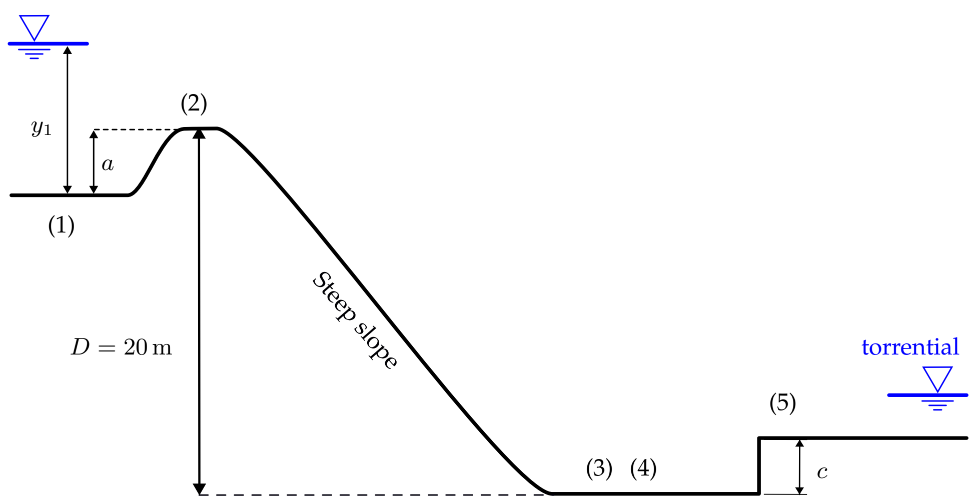

Figure 2: Schema of the spillway.

Objectives and guidance

This exercise focuses on using the concepts of specific energy, critical flow, the solving for water depth from a known head (iterative process) and considering head losses around a hydraulic jump. Combining these points, the hydraulic profile can be drawn for this exercise.