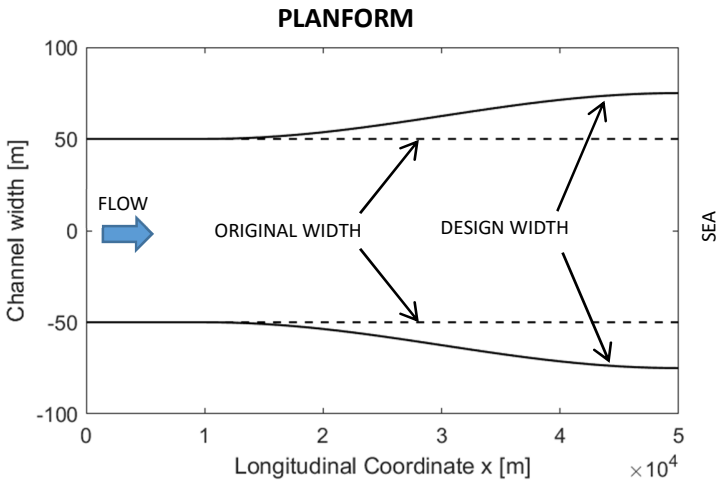
Fluvial Hydraulics and Morphodynamics (a.y. 2021/22)
Assignment December 2021

Consider the terminal L=50 km of a river channel debouching into the sea and characterized by a rectangular cross section with a constant width b_u and a longitudinal bed slope i_f. The sediment is uniform with a diameter d_s and relative density s. The Gauckler-Strickler coefficient is k_s. Assuming normal flow conditions (cross section NOT infinitely wide!) and employing van Rijn (1982) formula for both bedload and suspended load:

1. Evaluate the bedload transport capacity Q_{sb}, the suspended transport capacity Q_{ss} and the total load Q_s (= Q_{sb} + Q_{ss}) as a function of the flow discharge Q. Report the results both in tabular form, in one plot (Q, Q_s) indicating both the bedload and suspended load, and in one plot (Q, Q_{sb}/Q_s Q_{ss}/Q_s) showing the ratio of both bedload and suspended load to the total load.
2. Compute the value of the flow discharge Q_M and sediment transport Q_{SM} in present configuration (constant width) such that the normal flow depth $Y = 5$ m.

It is now suggested by local authorities to widen terminal reach of the river according to a sinusoidal function of the form:

$$\begin{cases} b = b_u & 0 < x < L_{up} \\ b = b_u + \frac{1}{2}(b_0 - b_u)\left[1 - \cos\left(2\pi \frac{(x - L_{up})}{L_b}\right)\right] & L_{up} \le x \le L \end{cases}$$



3. Calculate the gradually varied flow profile under the hypotheses of steady flow and fixed bed conditions for a flow discharge Q_M, a free surface elevation at the downstream boundary h_0, a bed level at the downstream boundary η_0 and a constant longitudinal bed slope i_f. Represent the result in a graph (x coord, elevation) showing the bed level elevation, the critical depth elevation and the free surface elevation.

4. With the values Q_M and Q_{SM} determined at point 2., compute the equilibrium configuration of the bed in the design configuration assuming that the free surface at the downstream boundary condition is still h_0.
   Report the solution both in a tabular form and as a longitudinal plot where the equilibrium bed elevation η_{EQ} and the equilibrium free surface elevation h_{EQ} in the design configuration are compared with the corresponding values in the present configuration.

5. Briefly discuss the implications of the channel widening on the flood hazard.

Input values:

- Channel width b_u = 100 m
- Longitudinal bed slope $i_f = 8 \cdot 10^{-5}$
- Sediment diameter d_s = 0.35 mm
- Sediment relative density s = 2.65
- Gauckler-Strickler coefficient k_s = 35 $m^{1/3}/s$
- Downstream water level h_0 = 0 m
- Downstream bed level η_0 = -5 m
- Design configuration:
  - b_o = 150 m
  - L_{up}= 10 km
  - L_b= 80 km