The XXXVIII International School of Hydraulics, 21-24 May 2019, Łąck, Poland

# River channel formation and response to variations in discharge, sediment and vegetation

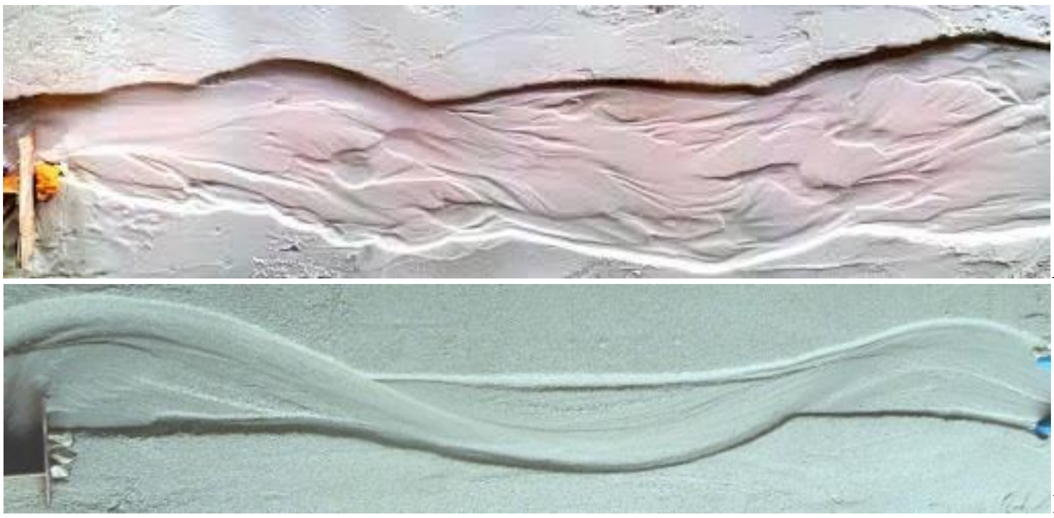
Alessandra CROSATO

IHE Delft Institute for Water Education, PO Box 3015, 2601 DA Delft, and Delft University of Technology, Dep. of Hydraulic Engineering, PO Box 5048, 2600 GA Delft, the Netherlands
email: a.crosato@un-ihe.org

## ABSTRACT

Alluvial river channels are excavated by flowing water capturing and transporting sediment along the way to the sea. Bed and bank erosion by water flow, combined with accretion processes, results in several river patterns:

- Wide and braided, mostly with gravel beds, presenting a network of multiple dynamic bars (Fig. 1, A).
- Transition, with a certain degree of sinuosity and sandy-gravel beds, presenting sequences of alternate and central bars. Here and there vegetation colonizing bar tops results in the formation of secondary channels.
- Meandering, with a sandy bed and cohesive vegetated banks, characterized by migrating bends presenting point bars and alternate bars (Fig., B).
- Anabranched, with vegetated islands separating rather stable channels.



A

B

**Fig. 1.** Cannels obtained in the laboratory with the same hydraulic conditions but different sediment heterogeneity. The sands used have the same median grain size ($D_{50}$ = 0.37 mm). A: braided channel obtained with uniform sand. B: meandering channel obtained with non-uniform sand (Byshimo, 2014).

Every alluvial river adjusts its morphology as a response to variations in water and sediment inputs, riparian and floodplain vegetation, as well as in the receiving water body (downstream boundary condition). Morphological changes can be observed at different spatial scales (Wright & Crosato, 2011).

They may involve bed forms (depth-scale), bars, bankfull channel width and depth (cross-sectional scale), sinuosity and longitudinal slope (reach-scale). Sinuosity and slope are thus dependent variables, just like all the other variables describing the river shape, but their evolution takes more time since it requires the displacement of larger volumes of sediment. For this reason in many approaches these two variables are assumed as constant.

The water discharge regime affects the channel morphology through the capacity of the flow to capture and transport sediment. The shape and size of the river depend on both average discharge and sequence of low and high flows, characterized by intensity and frequency (Wilkerson & Parker, 2011; Vargas-Luna et al., 2018a). Sediment processes are thus dependent on water flow, but they depend also on: input volumes, grain size and heterogeneity (degree of non-uniformity) of the sediment itself. Fig. 1 shows the effects of changing sediment heterogeneity in a laboratory flume. Vegetation on banks and floodplains increases the local hydraulic resistance, particularly during high flow events, concentrating the flow in the non-vegetated areas and enhancing opposite bank erosion. Anabrancing and meandering arise from vegetation colonising bars that emerge during low flows (Fig. 2). Water flow, sediment and vegetation processes are thus interrelated, but present also a certain degree of independency. The real independent factors governing them all are climate and local geology, but they are affected also by human interventions.

A B C

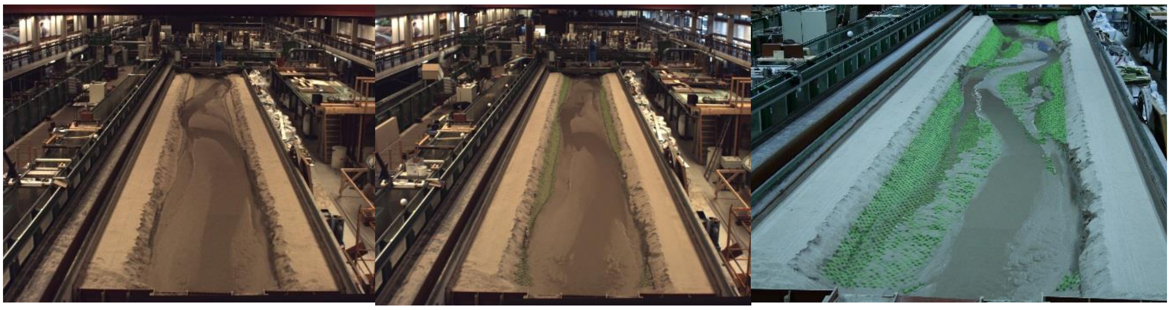


**Fig. 2**. Channels obtained in the laboratory with the same hydraulic conditions but different vegetation cover. A: channel without vegetation. B: channel with vegetation on banks. C: anabranching channel with vegetation on banks and on bars emerging during low flow (Vargas Luna et al., 2018b).

This contribution provides a review of the latest research developments highlighting the role of water flow, sediment and vegetation on the formation of river channels. Neglecting the role of geology, it illustrates how rivers respond to alterations in hydrological regime, sediment production and vegetation due to climate change and major human interventions, such as damming, land-use change and floodplain vegetation management.

## References


Byishimo, P. (2014). Effects of variable discharge on width formation and cross-sectional shape of sinuous rivers. Master Thesis, UNESCO-IHE, Institute for Water Education, Delft, The Netherlands

Vargas-Luna A., Crosato A., Byshimo P., Uijttewaal W.S.J. (2018a). Impact of flow variability and sediment characteristics on channel width evolution in laboratory streams. *J. of Hydraulic Research*, doi.org/10.1080/00221686.2018.1434836.

Vargas-Luna A., Crosato A., Anders N., Hoitink A.J.F., Keesstra S.D., Uijttewaal W.S.J., (2018b). Morphodynamic effects of riparian vegetation growth after stream restoration, *Earth Surface Processes and Landforms*, doi: 10.1002/esp.4338.

Wilkerson G.V. & Parker G. (2011). Physical basis for quasi-universal relationships describing bankfull hydraulic geometry of sand-bed rivers. *J. of Hydraulic Engineering*, 137(7), 739-753.

Wright N. & Crosato A., 2011. The hydrodynamics and morphodynamics of rivers. In: Peter Wilderer (ed.), *Treatise on Water Science*, Vol. 2, pp. 135–156, Oxford: Academic Press, ELSEVIER.