Final examination River Morphodynamics GEO3-4305 22-04-2005

1. Hydraulics

Does the flow in a tube, completely and only filled with water, shows a transition to supercritical with increasing flow velocity, and if so, what effect this will have on the hydraulic roughness? Explain your answer.

CHÉZY.

2. Hydraulic roughness of vegetation

The northern part of the east Chinese plain consists of silt and fine sand accumulations deposited by the Yellow River. In this area a silted up, old distributary is found which, due to the semi-arid climate and upstream withdrawal of water from the Yellow River for irrigation most of the time is completely dried up. However, in the wet season during the highest peak discharge some water may pass the channel. In order to protect the surroundings for flooding dikes have been built along the channel that rise 4 m above the (dry) river bed.

As a result of a prolonged period of dry conditions, the river bed between the dikes (200 m) shows a bare surface with some local patches of grass, cut very short due to the heavy grazing pressure by sheep. The highest water level reached after dike construction was 2 m below the top of the dike.

a. What is the hydraulic roughness (expressed in the Chezy-coëfficient) at the moment that the water level reaches 2 m below the top of the dike?

The local peasant community decides to plant a hardwood production forest over a large length of the river bed, covering the total width of the river plain between the dikes. Some data: grainsize data of bed material: $D_{50} = 80 * 10^{-6}$ m and $D_{90} = 110 * 10^{-6}$ m; The sediment has a density of 2650 kg/m^3. 20 years after planting the trees of the production forest are 10 m high. The slope of the river bed on average is 15 cm/km. The water temperature is 20^0 Celcius. The value of drag coefficient C_d related to the forest is 3. The acceleration due to gravity is 9.81 ms^{-2}.

b. Predict the water level at the situation that 20 years after planting of the forest the same discharge occurs that before, when the bed was bare, resulted in a water level that reached 2 m below the crest of the dikes.

3. Sediment mobility and flood discharge retention

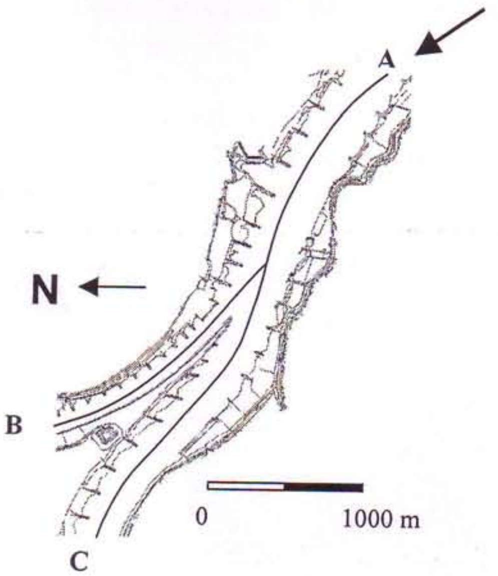
a. If the discharge of the river Meuse exceeds 3800 m^3/s, then a further increase of the water depth must be prevented. This will be done in the future with a retention basin (near the city Oss). Argue whether the retention basin has an effect downstream or upstream of the basin.

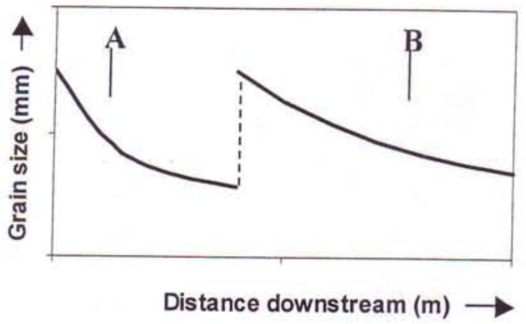
b. Because of their larger mass, coarse grains are generally less mobile than fine grains. In some rivers, however, coarse grains and fine grains start moving at exactly the same bed shear stress. This situation is called '*equal (entrainment) mobility*'. Give an explanation for the phenomenon of equal entrainment mobility (describe the process leading to equal mobility).

c. Given two situations: one with and one without the retention basin, we compare the mobility of the sediment in the armour layer at the peak discharge (which has been decreased in the case of the retention basin). This is necessary in order to predict unwanted downstream siltation of fine sand. The sediment in the armour layer has a D90 grain size of 30 mm (which is also the grain roughness), a median size of 8 mm and a D10 of 0.3 mm. The sediment behaviour deviates from equal mobility: the power of the equation 8 in the non-uniform sediment transport section of the syllabus is –0.7. The depth-averaged flow velocity without a basin is 3 m/s and with a basin is 30% smaller. The water depth without a basin is 7 m and with a basin is 6 m. Compute for both situations whether all the sediment of the armour layer becomes mobile during the flood (write down your computation steps).

4. Downstream fining

a. Is downstream fining impossible in rivers with equal entrainment mobility? Explain your answer.
b. At river bifurcations, the downstream fining pattern often shows a jump (see below). Name two *human* factors that can cause a downstream fining pattern as shown in the graph below.
c. Can a similar jump occur at a river confluence (flow in the opposite direction in the map below)? If not, why not, if so, how?





5. Morphology: hydraulic geometry and adaptation time and length

The Rhine developed a backbarrier delta in the Netherlands during the Holocene because the sealevel rose. Assume a bankfull discharge of 4500 m^3/s. The Rhine in this area is a sand-bed river with cohesive (clay and peat) banks and a channel slope of 2×10^{-4} m/m.

a. Compute the at-a-station bankfull width and depth of the Rhine using appropriate hydraulic geometry equations. Refer to the equation numbers/references/page you use in the book of Knighton and argue (short) why the chosen equations are appropriate.

b. We know that the Holocene Rhine built up its delta in the past 8000 years. Compute the De Vries time scale using an appropriate sediment transport predictor for the bankfull conditions and assuming a wedge-shaped delta volume of (1/2)x20x250x50=125000 km^3 from a sealevel rise of 20 m, a valley length of 250 km and a valley width of 50 km.
c. Why is the De Vries time scale much larger than the given 8000 years?
d. Compute/estimate how far land-inward the water depth adapts to the downstream boundary condition (the sealevel).
e. The value of the previous question is much smaller than the length of the Rhine delta (about 250 km), which roughly starts at Lobith. The length of the delta is here defined as the distance between the coastline (coastal dunes) and the point where the river channel slope suddenly decreases. This is, seemingly, a contradiction: the upstream adaptation of the flow is much smaller so how did the river adapt its slope to the sealevel rise that far upstream during the Holocene? Explain.