Netherlands Centre for River Studies

Nederlands Centrum voor Rivierkunde

Book of abstracts

NCR days 2017
February 1-3, 2017
Wageningen University & Research

NCR is a corporation of the Universities of Delft, Utrecht, Nijmegen, Twente and Wageningen, UNESCO-IHE, RWS-WVL and Deltares

A palaeohydrological study of a river pattern change in the Overijsselse Vecht

Jasper H.J. Candel*[1], Maarten Kleinhans[2], Bart Makaske[1], Wim Hoek[2], Cindy Quik[1], Jakob Wallinga[1]
[1] Wageningen University and Research, Soil Geography and Landscape group, P.O. Box 47, 6700AA Wageningen, The Netherlands
[2] Utrecht University, Department of Physical Geography, Faculty of Geosciences, P.O. Box 80115, 3508TC Utrecht, The Netherlands
** Corresponding author; e-mail: jasper.candel@wur.nl*

Introduction

Re-meandering is an important measure to restore the ecology in regional rivers (Lorenz et al., 2009). However, not all regional rivers have sufficient stream power to induce lateral migration (Kleinhans and Van den Berg, 2011). Re-meander approaches are still being applied to such rivers (Kondolf, 2006), which often results in failing river restoration projects (Wohl et al., 2015). In order to gain a better understanding of channel pattern changes (Schumm, 1985), we studied the historic morphodynamics of the Overijsselse Vecht. This is a sand-bed river flowing from Germany into The Netherlands, with a length of 167 km, a catchment size of 3785 km^2, a valley slope of $1.42*10^{-4}$ (Wolfert and Maas, 2007), and an average discharge and mean annual flood discharge of 22.8 and 160 $m^3 s^{-1}$, respectively. Before the channelization in 1914, lateral migration rates reached up to 3 m yr^{-1}, as was observed on historical maps for several meanders (Wolfert and Maas, 2007). Some of these meanders eroded deeply into the valley sides since approximately 1500 AD (Quik, 2016). We hypothesize that the river also changed from a laterally stable river into a meandering river ca. 500 years ago. The aim of this research is to elaborate upon the changes in forcing that have caused this river pattern change.

Lateral stable phase

The first step was to identify the palaeochannel that was active prior to the meandering phase. In Fig. 1 this channel is indicated with an arrow. We hypothesize that this channel was longitudinally connected to the first swale of the meander bend in a period of lateral stability. A radiocarbon date (^{14}C) of the channel bottom and an optically stimulated luminescence date (OSL) of the inner bank was taken in order to test this hypothesis (in progress). In addition, we determined the channel dimensions by coring in a transect perpendicular to the channel.

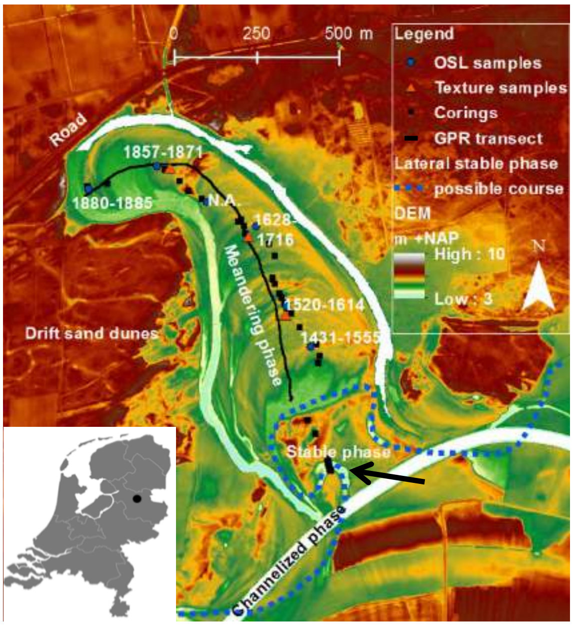

Figure 3 Digital elevation map (0.5x0.5m) of one of the studied bends in the Overijsselse Vecht. The arrow points at the palaeochannel potentially dating from the laterally stable phase. The blue dashed line shows the possible course of the channel. OSL dates are from Quik (2016).

Meandering phase

In the next step, we determined the channel dimensions during the meandering phase assuming the rules proposed by Hobo (2015) (Fig. 2). From the coring data reported by Quik (2016) we determined the bankfull depth (H_{bf}), taken from the bottom of the channel lag to the surface elevation in the swales. The transverse bed slope α was determined by using ground-penetrating radar (GPR) in a transect perpendicular to the scroll bars.

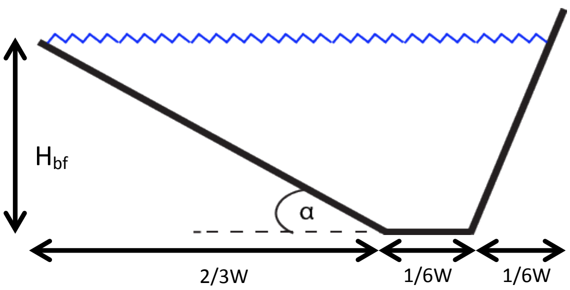

Figure 4 Sketch of the cross-sectional flow area of a meandering channel used for the palaeo-bankfull discharge calculations (Hobo, 2015, p.122).

Palaeodischarge

The bankfull palaeodischarge was reconstructed for both phases (laterally stable and meandering) following from the reconstructed dimensions and flow resistance estimated in four different ways: 1) by applying Brownlie's formula (Brownlie, 1983), 2) by estimating a Manning's roughness coefficient following the procedure of Cowan (1956), 3) by determining the Chézy value for a large dataset of 127 rivers, and 4) for 29 comparable rivers with scroll bars (Kleinhans and Van den Berg, 2011). Subsequently, the potential stream power and bar regime were predicted applying relationships of Struiksma et al. (1985) and Kleinhans and Van den Berg (2011). Monte Carlo simulations allowed us to take into account the statistical uncertainty of all parameters. Our analysis suggests that the bankfull discharge increased with a factor 2 to 3 around 1500 AD, resulting in a higher potential specific stream power (Fig. 3), and a river changing from an overdamped into an underdamped regime.

We suggest that the increase of the bankfull discharge is likely the result of land use changes in the catchment. In this period, reclamation of the margins of peatland areas intensified for buckwheat cultivation (Borger, 1992), lowering the hydrological buffer capacity of these peatlands (Streefkerk and Casparie, 1987). In addition, bank instability caused by intensive use of the floodplains for cattle grazing can explain why these large meanders only formed locally (Trimble and Mendel, 1995; Quik, 2016).

Our study provides improved understanding of channel pattern transitions and associated forcings in lowland areas. Such information supports the design of sustainable river restoration.

Acknowledgements

This research is part of the research program RiverCare, supported by the Dutch Technology Foundation STW, which is part of the Netherlands Organization for Scientific Research (NWO), and which is partly funded by the Ministry of Economic Affairs under grant number P12-14 (Perspective Programme).

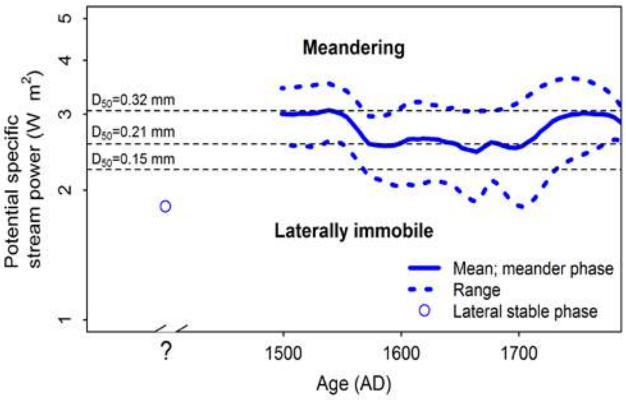

Figure 5 Stability diagram in which both river pattern phases are plotted, with the discriminators of different bed textures (Kleinhans and Van den Berg, 2011).

References

Borger, G. J., 1992, Draining—digging—dredging; the creation of a new landscape in the peat areas of the low countries, Fens and bogs in the Netherlands, Springer, p. 131-171.

Brownlie, W. R., 1983, Flow depth in sand-bed channels: Journal of Hydraulic Engineering, v. 109, p. 959-990.

Cowan, W. L., 1956, Estimating hydraulic roughness coefficients: Agricultural Engineering, v. 37, p. 473-475.

Hobo, N., 2015, The sedimentary dynamics in natural and human-influenced delta channel belts.

Kleinhans, M. G., and J. H. Van den Berg, 2011, River channel and bar patterns explained and predicted by an empirical and a physics-based method: Earth Surface Processes and Landforms, v. 36, p. 721-738.

Kondolf, G. M., 2006, River restoration and meanders: Ecology and Society, v. 11, p. 42.

Lorenz, A., S. Jähnig, and D. Hering, 2009, Re-Meandering German Lowland Streams: Qualitative and Quantitative Effects of Restoration Measures on Hydromorphology and Macroinvertebrates: Environmental Management, v. 44, p. 745-754. 10.1007/s00267-009-9350-4

Quik, C., 2016, Historical morphodynamics of the Overijsselse Vecht: Extreme lateral migration of meander bends caused by drift-sand activity?, Wageningen University & Research, Wageningen.

Schumm, S., 1985, Patterns of alluvial rivers: Annual Review of Earth and Planetary Sciences, v. 13, p. 5.

Streefkerk, J., and W. Casparie, 1987, De hydrologie van hoogveen systemen: Staatsbosbeheer-rapport, v. 19, p. 1-119.

Struiksma, N., K. Olesen, C. Flokstra, and H. De Vriend, 1985, Bed deformation in curved alluvial channels: Journal of Hydraulic Research, v. 23, p. 57-79.

Trimble, S. W., and A. C. Mendel, 1995, The cow as a geomorphic agent—a critical review: Geomorphology, v. 13, p. 233-253.

Wohl, E., S. N. Lane, and A. C. Wilcox, 2015, The science and practice of river restoration: Water Resources Research, p. 5974-5997. 10.1002/2014wr016874

Wolfert, H., and G. Maas, 2007, Downstream changes of meandering styles in the lower reaches of the River Vecht, the Netherlands: Netherlands Journal of Geosciences v. 86, p. 257.