Morphodynamic Design for River Restoration

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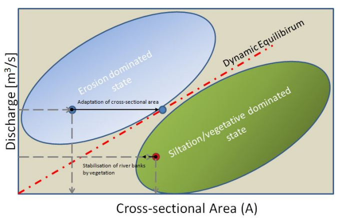
When talking about the success of river restoration it is often looked at the ecological state of the river rather than the physical state. Improving the ecological state is however determined by restoration of the physical processes in the river such as bed load transport and spiral flow in meander bends.

Improving the ecological state of the river largely depends on the ability of the river to rejuvenate: to cut-off banks and form new point bars. Many recently restored Dutch rivers show a lack of this so-called *morphodynamic* behavior due to:

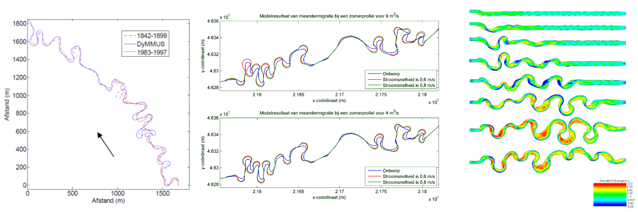
- Relaxation of restoration ambitions as a compromise to diminish the environmental impact (land use and ground water table changes)
- Lack of river basin approach – no source restoration;
- Restoration of short transects, often leaving existing weirs in place;
- Application of a simplified approach to derive parameters for cross-section and plan view;
- Assumptions on hydrological parameters are wrong (design based on *stationary* simulations representing a *dynamic* behavior)



Top: Schematic scheme showing the balance between the channel forming capacity of the river after restoration or fixation of the channel due to vegetation growth.

When designing a new channel, the aim should be to achieve a channel in the erosive state. Once the channel reaches the siltation state, the dynamics vanish.

Down: 1D and 2D meander migration modeling (1D DyMmus, 2D NAYS)



Morphodynamic approach:

- The natural character of the river is estimated using empirical relations to derive cross-sectional parameters (e.g. depth, width) and plan view parameters (e.g. meander radius, sharpness of the meander bend) and historical maps for verification.
- 1D hydraulic modeling to provide indicative values for flow velocity, a measure for river dynamics.
- Indicative assessment of results using general standards for river restoration;
- In-depth morphodynamic assessment using 1D2D Meander Migration Modeling leads to:
    1. Verification of parameters derived from the empirical analysis;
    2. Required space occupation for meandering;
    3. Risk reduction → avoid damage of properties by showing locations of bank erosion and speed of bank retreat;
    4. Communication tool: showing result of investments in river restoration to stakeholders and residents;

Case Study: River restoration Kleine Beerze River, Holland

Situation

- Unconsolidated sandy substrate, low valley gradient;
- Historical land use planning has changed hydrological regime as well as channel characteristics.

Objectives

- Improvement of hydro-ecological situation of the river valley
- Protection and enhancing development of species under the Habitats Directive.

Methodology

- Application of Morphodynamic approach;
- Reserve suitable locations – remnants of straight sections - for preservation of Floating Water Plantain.

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Monitoring results

- According to WFD criteria the ecological state has not improved much;
- Highly varying hydrological regime – dry bed during significant parts of the year – affects the dynamic behavior of the river. River dynamics cannot prevent vegetation growth;
- Inflow of nutrient rich water continues, lack of "source restoration"

Successes

- Local variation in river dynamics due to smaller profile and sharp meander bends has led to semi-dynamic river;
- Water storage capacity has increased, water logging of the river valley;
- Red list species *Luronium natans (*Floating Water-plantain) develops rapidly in old channel remnants. Other red list species (e.g dragonflies) have returned due to improved morphodynamic conditions.

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