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# The multi-channel concept explored from Bonn to Biesbosch

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## Introduction

The hydro-morphology of the Rhine River has significantly altered due to engineering interventions since the 18th century. These interventions improved navigability and reduced the risk of ice dams. Especially in the Waal River, normalization led to channel bed incisions at a rate of 1–2 cm per year (Blom, 2016). This has resulted in a 1–2-meter degradation of the riverbed in the Waal since the 1950s (Blom, 2016). In the business-as-usual scenario, the riverbed is expected to incise by up to 1.5 meters in the next 50 years (Yila Arbós, 2024). The incision causes shipping bottlenecks, affects the stability of infrastructure and groynes, undermines freshwater intake points, and impacts the ecological quality of floodplains (Beekers et al., 2017). Therefore, action is needed.



Figure 1. Principle of the multi-channel concept. By widening the wetted perimeter, the energy is better divided through summer and winter bed.

In this paper, we explore the multi-channel concept that was developed by Bureau Strooming, WWF and ARK Rewilding to reduce erosion while improving natural quality without affecting navigability. Due to the bypasses the flow velocity in the summer bed decreases, reducing erosion (Figure 1). Exploratory calculations show that large-scale floodplain lowering could potentially reduce the necessary sediment supplementation

volume to counter incision by 14–33% (Barneveld et al., 2019).

## Method

We evaluate the Lower Rhine from Bonn (GER) to Biesbosch (NL). Because this trajectory is a lowland river, we consider this a logical boundary for a systematic approach to challenges such as morphology, water safety, water quality and ecology. Despite the Niederrhein, up to Bonn, which has been fairly stable since 1985 due to continuous sediment nourishments it could benefit from the multi-channel concept (Frings et al., 2014). It reduces the required sediment volume, improves water quality in line with the Water Framework Directive goals, and contributes to the EU Nature Restoration Law. By creating more room for the river, it could enhance water safety along the Niederrhein.

Therefore, in this study, the multi-channel concept from the Waal River is extended with a design for the Niederrhein. Which is based on on topographical, geomorphological, and fundamental river flow principles. Separate SOBEK Flow1D models for the Niederrhein and Dutch Rhine trajectories are combined, allowing assessing the hydrological effects of the multi-channel concept on a broader system scale. Tributaries are excluded from the model. Together with the existing designs—including widths and depths—for the Gelderse Poort and Waal, the bypasses are implemented in SOBEK (Figure 2). Using multiple discharge scenarios, the water level reduction and decrease in flow velocity can be determined. Given the large scale of the study area, a one-dimensional approach has been applied.

## Results & discussion

Model runs have been performed with discharges of 450, 2,200, 7,000, and 12,730 m<sup>3</sup>/s. Observation points at every kilometre along the trajectory indicate the effects on water level and flow velocity. During average discharge, the model shows a decrease in

flow velocity across almost the entire river section (Figure 3). However, this reduction diminishes as discharge increases. With this study initial steps have been taken toward developing an applicable model for gaining further insight into the hydrological effects of the implemented bypasses.



Figure 2. Example of an implemented bypass in the Sobek Model

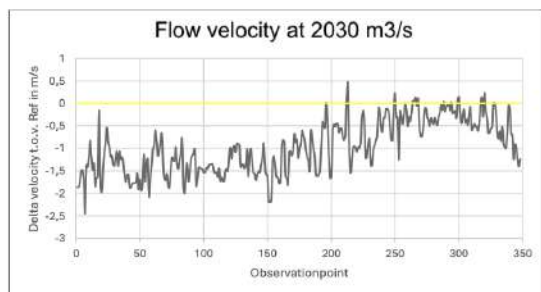


Figure 3. Flow velocities for the multi-channel concept

Further optimization and validation of the model are required to fully utilize its potential. Once optimized, the model outcomes can be linked to various river characteristics for better understanding of the results in relation to river geometry, levees etc. This will contribute to optimizing the multi-channel design along the river profile, which is the overall goal of this study. Based on these results, and the study of sediment balance in the Rhine from Frings et al. (2012) and Frings et al. (2019) exploratory calculations can be conducted to indicate the effect on the needed sediment volumes.

### Future research

In contribution to the 1D SOBEK model a 2D model can be conducted using floodplains representative for the trajectory to gain better understanding on the effects on smaller scale. In the process of optimizing the design by finding a right balance for multiple function such as ecology, navigation, and morphology we think assessing designs that maximize a single river function can be useful. Through this approach the design boundaries are clarified in which an optimal design can be achieved.

As the Room for the River 2.0 program and PAGW 'Gelderse Poort' are currently assessing the potential implementation of the multi-channel

concept, we believe aligning theoretical research with the program's challenges will accelerate the concept's transition. As the concept is relatively new, many questions remain unresearched. To prioritize which challenges should be addressed, we propose a cooperative approach in which we conduct a discussion to determine the knowledge needs, leading to an improved and detailed design of the multi-beam concept between Bonn and Biesbosch while acknowledging the different river functions.

After cooperatively identifying a research focus, the design can be optimized and modelled to gain insight into the hydro morphological effects. The concept can then be developed further. Through this method, a research direction can be formulated such that the outcome directly benefits the ongoing development of the concept. In preparation for this discussion, a literature review and knowledge sessions with experts will clarify the current knowledge gaps in the multi-channel concept, which can then be discussed and prioritized during the discussion

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