DEVELOPMENT OF FRESHWATER MUDFLAT ZONES AND TIDAL CREEKS FOLLOWING AN INITIAL DESIGN SUPPORTED BY MORPHODYNAMIC MODELLING

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INTRODUCTION

As part of its flood protection strategy, the Senate of the the Free and Hanseatic City of Hamburg is planning dike relocations shifting inland as coherence planning measures. This is because raising the dike sometimes encroaches on the natural conservation area that needs protection and thus compensation, simply as the new dike geometry demands a larger area. One possibility of mitigating this impact is to increase the ecological value of the newly created riparian area. That can be achieved by the formation of freshwater mudflats with corresponding tidal creeks connected to the estuary, which develop on the floodplains created by the relocation of the dike. In this setting, anthropogenic tidal creeks are created with a connection to the tidally influenced River Elbe. Anticipating the morphological development at this location, the topographic design of these creeks must be planned in such a way that they remain in a stable morphodynamic equilibrium for the medium and long term. This is to ensure a lasting coherence effect of the planning measures.

METHODOLOGY

The aim of this paper is to present the methods for estimating morphodynamic developments and the adaptation process of artificially created tidal creeks. Of particular interest here is the time-scale at which the morphological changes to the tidal creeks can be expected. Furthermore, it is investigated what time period it takes to achieve a morphologically stable dynamic equilibrium and how this equilibrium state can be identified.

For this purpose, the Agency for Roads, Bridges and Waters (LSBG) of the Free and Hanseatic City of Hamburg uses the Delft3D Flexible Mesh modelling software from Deltares. The hydrodynamic numerical and morphodynamical model performed simulations covering time periods from a few weeks (Spring-Nipp Cycle) up to 20 years. Empirical methods such as the calculation of shear stresses for erosion stability, the MORAN method (Siefert, 1987, Gönnert, 1995) or Exner's equation (Exner, 1925, Coleman, 2009) are applied in parallel to the model calculations. They are used to analyse the calculated temporal changes of the tidal creek geometry as well as its respective state with regards to a development towards a morphological equilibrium condition. The combination of morphodynamic simulations and empirical analyses is intended to increase the robustness of the simulation results over several years. In addition, the spatial redistribution analyses carried out in the MORAN procedure can be used to record the floodplain area where high morphodynamic activity can be expected and where a long-term dynamic equilibrium is maintained.

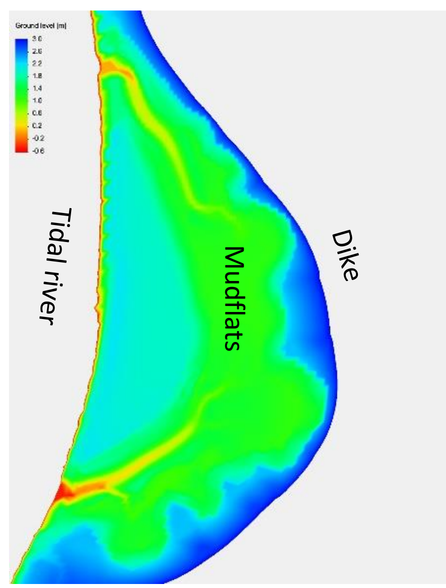

Figure 1 Simulation results of mudflat zones with tidal creeks along a tidal river

An initial morphodynamic simulation is carried out in order to generate an initial state of the floodplain topography in which the position and dimensioning of the tidal creek is as close as possible to that of a natural development for the given hydrological and sedimentological conditions. With already provided connection to the tidally influenced river Elbe (see Figure 1), a morphodynamic model simulation is carried out for natural development and shaping of the floodplain tidal creeks and their shore areas. This floodplain topography, with its naturally developed tidal creeks, provided stimulus for the long-term morphodynamic simulations. This ensures that the natural morphological developments taking place since the completion of initial state have only got residual effect that is solely due to the hydraulic boundary conditions such as spring-neap cycle, storm surges, and varying inland river discharge. From this point onwards, fully developed vegetation is also included in the simulations. By varying parameters such as bed material and suspended sediment concentrations, valuable insight can be gained into the uncertainties that may be inherent in the modelling results that are obtained in different areas of the floodplains.

RESULT

As a result of initial and long-term morphodynamic simulations, along with the analysis of dynamic stability, floodplain topography with tidal creeks will be developed. This is also in line with the nature conservation requirements with regard to the desired coherent effect for the flood protection construction programme.

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