

# FORESHORE PILOT PROJECT FOR HOUTRIB DIKE - General final report

## Context

The stated aim of the foreshore pilot project for the Houtrib Dike was to establish a firmer basis for faster sandy dike-strengthening operations, in particular in the load conditions in the larger lakes. The results from the project have now been applied in both present and future projects covered by the Flood Protection Programme. One of those projects is the strengthening of the Markermeer dikes between Hoorn and Edam in the Netherlands, which includes a sandy reinforcement approach (the 'shore dike'). The knowledge generated by this pilot project was also used to determine the dimensions for the sandy reinforcement of the western section of the Houtrib Dike and the sandy outer edges of the Marker Wadden.

## Abstract

This report is the final version of a 'living document' that discusses the very latest results and insights from the pilot project in an interrelated way. The present version of this general report is an update of the interim version of February 2018 (EcoShape, 2018a). The working plan underlying these studies was used as a basis (EcoShape, 2015a). That plan can also be seen in the design and set-up of this general report, which devotes a separate section and one or more products to the discussion of all the research topics considered.

In addition to a general section, this general report also consists of five report sections in the annexes and the description of seven products in the appendices. The first part of this report looks at the analysis of the monitoring results and how that has been worked up into the basic information used to answer the research questions. During the operational phase of the pilot project, this report was also explicitly adopted as the guiding document for the detailed discussions in the underlying working documents.

The present version of this report describes the final state of affairs. The reader is referred to the underlying reports for further details. An important aim of the pilot project was to deliver guidelines and lessons learned about permit procedures and construction. In addition, guidelines were produced for design, management and maintenance, as well as a business case for sandy foreshores. These are available in separate documents.

## Complementary research

In the final months of last year, work began on the complementary research that was decided on in mid-2017 (EcoShape, 2017b and EcoShape, 2017c). That research focused on improving our understanding of the function and mechanisms of the plateau that developed on the foreshore. It consisted of two parts: physical measurements (wave heights, speeds) on the plateau and the monitoring of the effect of the local excavation of this foreshore.

The detailed results of the analysis of these additional measurements can be found in two underlying reports (EcoShape/Deltares/HKV, 2018 and EcoShape/Arcadis, 2018). The first report contains the results of the physical measurements and the adaptation of the morphological calculation model XBeach based on those results. The second report looks in more detail at the explanation of the observed effects of the partial excavation of this foreshore. The broad outlines of these detailed reports can be found in the present report.

## Findings

With regard to morphological development, it can be concluded that the profile section is relatively stable, despite sometimes extreme hydraulic conditions with waves of up to 1.2 m prior to removal in mid-2018. This applies not only to the whole of the sandy triangle that was created but also to the cross-section perpendicular to the shoreline. The sediment balance was virtually closed. A further analysis of the composite morphology shows that a clear

distinction can be made between the development of the lower foreshore, which gradually links up to the sheet piling installed transversely on the dike, and a higher section that responds faster and which varies in terms of orientation depending on changes in the prevailing wave direction.

In the transverse direction, the profile section directly affected by the wave direction that is situated, broadly speaking, above NAP –1 m includes a stable profile consisting of a relatively steep section (slope angle in the order of 1 : 10) around the waterline below a 'swash berm'. The development of the profile seems to be related at least to the presence of relatively coarse material and grading effects. The typical correlation between the local water level and the wave height at this location also plays a role here.

It proved difficult to get vegetation to grow around the waterline of the test section. Attempts in this respect were unsuccessful and they concur with results elsewhere indicating that reed vegetation cannot cope with waves higher than about 20 cm. On the slightly higher section, the vegetation did thrive, in part because of the irrigation use in the initial phase. Mixing with the Holocene top layer also appeared to have a beneficial impact. The impact on the vitality of the vegetation introduced caused by birds that graze on the plants was, at least initially, clearly negative. Eventually, more and more vegetation grew on the parts of the trial section that were not planted (EcoShape/Deltares/WER/HKV, 2018).

(afbeelding invoegen)

Aerial photos were taken in September 2014, June 2016 and June 2017 (see pictures above) and they showed that the vegetation has grown even more. The boundaries between the various test sections are still clear to see.

### **Completion and prospects**

The test section has now been handed over to the project team that is reinforcing the entire Houtrib Dike. The containment dam is serving as the eastern protection for an operations port. Both the Holocene top layer and the vegetation have been removed from the test section and the relatively coarse sand package has been used for a different purpose.

With a view to further knowledge development, we are now working on a restart of the analysis and monitoring programme for the sandy edges of the Markermeer lake. Consultations are taking place in this context about the monitoring programme for the Houtrib Dike reinforcement, which will be linked to the research taking place on the sandy edges of the bird islands in the context of the Marker Wadden Knowledge and Innovation Programme (KIMa) (KIMa/Arcadis, 2018). A direct link has also been established with the monitoring programme, which still has to be elaborated in detail, for the 'shore dike' alongside the northern Markermeer dikes. This makes it possible to work on the objective stated in the 'Beter leren keren' proposal drawn up by ENW, which involves setting up cross-project monitoring in order to be able to answer the remaining knowledge questions in the most effective way.

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