

# Ecobeach

Investigations for a natural stabilization of the coast



Translation by BAM



## Contents

<i>Ecobeach: a natural solution?</i>	5
<i>Cooperation between the private and public sector</i>	7
<i>The field tests</i>	8
<i>Results</i>	9
<i>Extensive measurements</i>	13
<i>Recommendations for further studies</i>	16

# Ecobeach: a natural solution?

*In the early 1990s the Danish contractor Poul Jakobsen (1947) accidentally discovered a mechanism to naturally stabilize the coast line. During his works on a Danish sand beach he installed vertical tubes for drainage. When the works were finished, the beach suddenly appeared to have grown. After this remarkable discovery, Jakobsen started to perform tests with the drainage tubes which he called Pressure Equalizer Modules (PEM), and obtained promising results.*

In 2005 the contractor Royal BAM Group proposed to the at that time ministry of Transport, Public Works and Water Management to apply PEM in The Netherlands under the name Ecobeach. Following this, from 2007 to 2010 Rijkswaterstaat and BAM performed field tests on the beach in Egmond aan Zee where Poul Jakobsen was also involved.

## Theory and practice

The theory behind Ecobeach is simple: The vertical drainage tubes ensure that less sand is taken (back) to the sea by the water. This way, the beach can slowly grow. When proven successful, Ecobeach can be installed in combination with foreshore nourishments as a cheaper alternative to expensive beach nourishments. The nourishments to sustain the coast line are applied using special vessels which dredge the sand onto the beach (beach nourishments) or into the shallow waters in front of the beach (foreshore nourishments).

However, indifferent of how promising the method seems, a sound scientific proof of the mechanisms is still missing. To investigate the working mechanism in 2007 Rijkswaterstaat and BAM installed the vertical drains at two test sites. For a comparison one area was declared as a reference site where Ecobeach was not installed. Initially, it was planned to conduct the tests over 3 years but during this time it was decided to extend the measurements by another year until 2010.

## Scientific debate

The principle of research in the area of flood protection is to first formulate a hypothesis about how something works and afterwards to prove it through tests. In contrary, for empirical studies measurements are often the basis upon which conclusions are drawn. This is also the case for Ecobeach: The beach is growing, but exactly how this works cannot yet be said at the beginning of the tests.

The results obtained up to now and the role that Ecobeach played in it are difficult to explain with the existing scientific insights. This led to a large debate in Denmark, as well as in The Netherlands. As the possible working mechanism cannot be explained with existing theories the conclusion which is quickly drawn is that then it cannot be working. However, the results are very promising, therefore also Rijkswaterstaat is interested in further research.

The research institute Deltares performed the analysis of the results for Rijkswaterstaat. Again, a debate arose about how to interpret the results and which conclusions to draw from them. Concerning this, it should be mentioned that Rijkswaterstaat and BAM do not agree with all the interpretations and conclusions made by Deltares.



# Cooperation between the private and public sector

*The central point during the tests was the cooperation between Rijkswaterstaat and BAM within the innovation project. Such an intensive cooperation between a governmental institution and a private company was definitely extraordinary. Together, they investigated the following questions: does the system work, and if so, what is the working mechanism behind it?*

## A good deal

The two parties made the project attractive for each other through good agreements. Rijkswaterstaat provided the testing location; the construction company BAM offered their services on a 'no-cure-no-pay' basis and received a bonus if the beach was to grow. This was a special situation since the financial commitments were made without specifying and knowing in detail what the outcome of the tests would be. This was also the first time that such a financial incentive had been incorporated in an innovation project of Rijkswaterstaat. The collaboration was in the meantime regularly evaluated and both parties are referring to a "good communication and open relation".

## Self-initiative through collaboration

Companies and public institutions are used to working with each other. But the cooperation in an innovation project with shared responsibilities and costs, as for Ecobeach, is really something special. The collaboration between BAM and Rijkswaterstaat was initiated by BAM and the project started smoothly thanks to a number of enthusiastic people at BAM and Rijkswaterstaat.

# The field tests

## Two test sites

Ecobeach was tested at two locations of three kilometres length each. The northern test area is located near Egmond aan Zee between kilometre 36 and 39. The southern test site is located between Egmond aan Zee and Castricum aan Zee between kilometre 40 and 43. The reference area – also 3 kilometres in length, but without drainage tubes – is located directly south of this.

## Pressure equalizing Modules: 629 drainage tubes

The pressure equalizing modules – PE-tubes with a length of 1.75 m – were placed vertically, about 25 cm below the beach surface. In the northern test area, 296 tubes were installed, at the southern test site 333 tubes were placed, leading to a total of 629 tubes. Every 100 meters a row of tubes was placed perpendicular to the beach line with a distance of 10 m between the tubes. Every row consisted of 6 to 14 tubes, depending on the width of the beach. The installation took about 3 months: from the 13<sup>th</sup> of November 2006 until the 15<sup>th</sup> of February 2007. Then the system was installed completely.

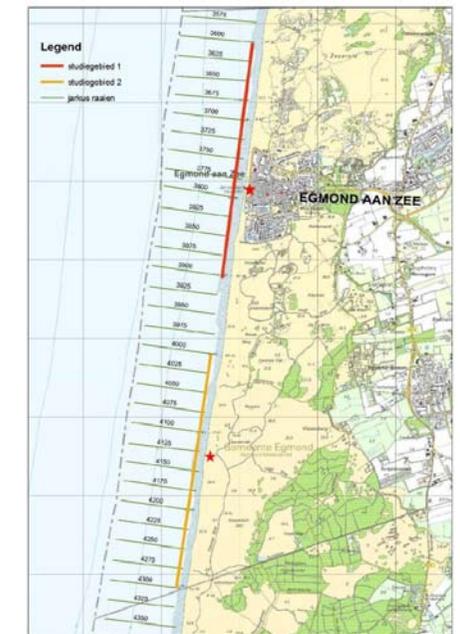
## Cost

The total cost of the project was 960,000 € which can be split into:

- Installation, license, investigations, maintenance, removal: 510,000 €
- Monitoring and analysis: 450,000 €

## Partners

Rijkswaterstaat and Hoogheemraadschap Hollands Noorderkwartier are involved as the administrators of the beach. Also, the municipality of Bergen was asked to participate in the project and showed great interest and enthusiasm for it; a larger, wider beach always leads to more recreational opportunities. The municipality organized informational events for residents. The Vrije Universiteit Amsterdam and the Technical University of Delft supported BAM with the scientific tests and the research institute Deltares was involved with the scientific preliminary studies, monitoring and analysis.



The second test area for Ecobeach (source: Deltares)

# The results

*During the tests, more sand accumulated on the beach than was expected. Also, the composition of the sand changed during the test period. The results are very promising but cannot be related one-on-one to the Eco beach system. For that, the possible influence of other factors is still not clear enough. BAM and Rijkswaterstaat made a number of interesting discoveries during the tests.*

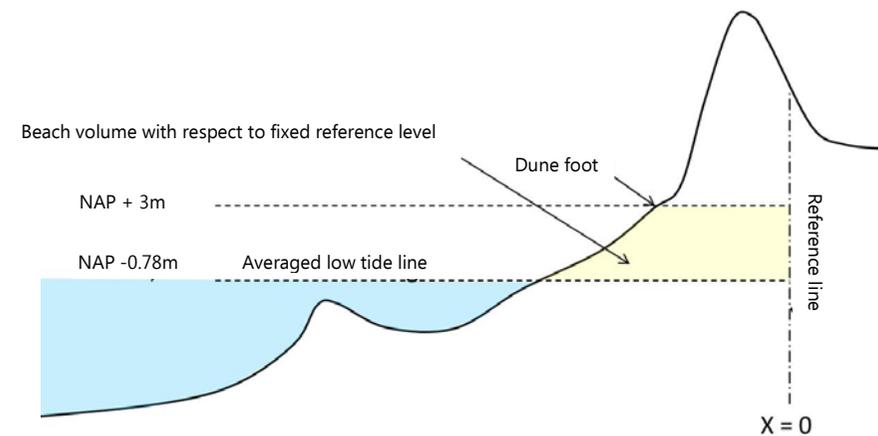


During the tests, the following observations were made:

- At the beach in the southern test area, circa 115,000 m<sup>3</sup> of sand accumulated – measured over a length of 2750 meters of beach – during the project (2007 – 2010).
- The beach became wider.
- The beach in the reference area also grew.
- Sand transport took place and the dunes grew.
- 2.5 years after the beginning of the tests, the sand in the southern test area was 30 % coarser than in the neighboring areas. The median grain size was approximately 400  $\mu$  and the coarser sand was located in the top 2 m.
- Due to the digging during the removal of the tubes locally quicksand occurred.
- An interesting observation: After the tests and after removal of the tubes, the beach volume decreased in both the test and reference areas.

## More sand

In 2007 the drainage tubes were installed 25 cm below the beach surface. When they were removed at the end of the test period, some of them were located more than 1.50 m below the sand. During the test period from 2007 to 2010 the beach at the southern test area grew by about 50 m<sup>3</sup> per meter of beach. The beach volume, both in the test area as well as in the reference area, was significantly larger than predicted based on the available data from the previous years. After the tests and after the removal of the tubes, the beach volume decreased in both areas.



### Coarse sand

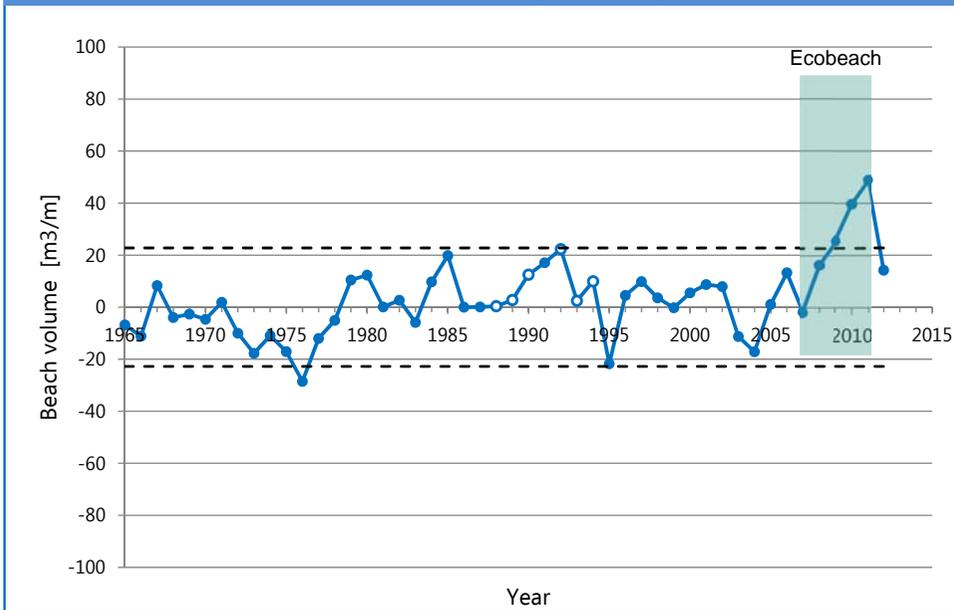
It was striking that the students from the TU Delft found coarser sand in the test areas compared to the reference area. The median grain diameter in the test area was about 30 % (100  $\mu$ ) larger than in the neighboring areas: 397  $\mu$  versus 305  $\mu$ . In the middle of the southern test site the grain diameter even reached 490  $\mu$ . These larger grains were only found in the upper 2 m below the surface, in the so called active zone. The coarser sand was not found during earlier measurements.

Also in test areas in Denmark, students found coarser sand. Coarser sand leads to steeper and more stable beaches and provides a better drainage. Therefore, the beach dries faster after flood tide. Moreover, it seems that at the ebb water line fresh water flows out of the system. This indicates a vertical water transport through the drainage tubes since the deeper ground water is relatively fresh.

### Complexity

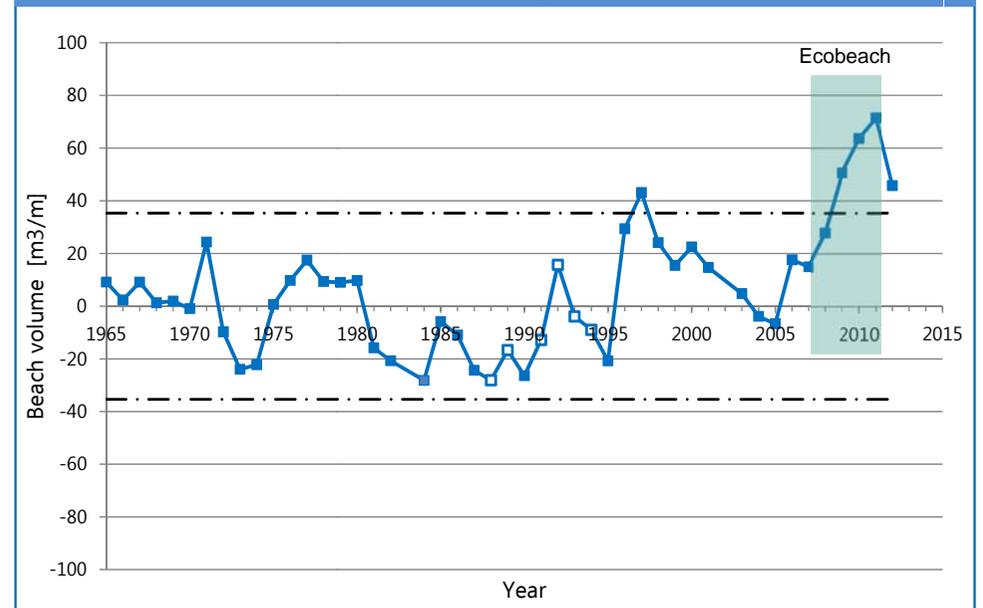
The Dutch coastal system is very complex and dynamic and many processes have an influence on the development of the coast. These include for example the natural variations due to currents and waves, the progression of sandbanks, and the effects of nourishments. It is not completely clear how these factors influence another and which is/are the dominant factors. Nevertheless, it is for sure that through waves, tides, and storms large amounts of sand are mobilized which has an influence on the width of the beach, the location of the coast line, the beach volume, the dune volume, and the location of the foot of the dune (the transition between the beach and the dunes). Because of this complexity it is for example hard to measure the exact effects of nourishments and this is also the case for the Ecobeach tests.

Beach volume in the test area south, 3 km average, with respect to fixed reference line



The dotted line show the 95 % confidence interval for the 1965 – 2006 data

Beach volume at the reference site, 3 km average, with respect to fixed reference line



The dotted line show the 95 % confidence interval for the 1965 – 2006 data

# Extensive measurements

*Rijkswaterstaat and BAM have performed extensive measurements. Besides others, the 'jaarlijkse kustmetingen' (the yearly coastal observations, hereafter referred to as JARKUS measurements), Differential Global Positioning System measurements (referred to as DGPS-measurements), 'Water En Strand Profiler' (water and beach profiler hereafter referred to as WESP), and the Argus video system were made use of. Further, various sediment tests were performed.*



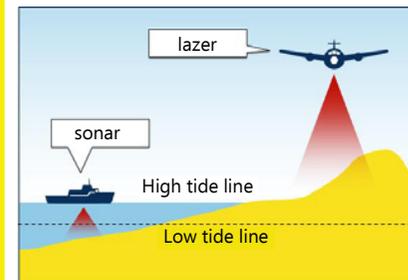
Students of the Vrije Universiteit Amsterdam and the Technical University of Delft performed investigations, amongst others, on grain sizes and the ground water behavior. Dutch scientists and researchers from various universities, institutes and companies were involved with Ecobeach.

Together, they discussed the test set-up and the possible principles of operation of the system. Afterwards, the results were reviewed with all parties and the conclusion from the researchers is that at the current knowledge of the coastal morphology is insufficient to clearly explain the results of the Ecobeach experiments. For this, further research is necessary.

## The Measurements

### Yearly coastal observations

Since 1964 during every spring the JARKUS-measurements are performed along the entire coast. Every 250 m a line of about 2 km is measured from about 15 m below sea level up to and including the first dune line. Under water this is done with sonar equipped vessels and on land the survey is performed using laser equipped airplanes (see Figure below). During the Ecobeach tests these measurements were more extensive so that in the fall additional, closer measurements were taken in the water which were spaced about 100 m apart.



### DGPS measurements and WESP

In addition to the JARKUS measurements, the elevation profile of the beach up to the dunes was determined on a (bi-) monthly basis using DGPS measurements. The WESP (Water and beach profiler) was used for specific measurements in the intertidal zone.

### Argus video system

Both test areas were monitored through the Argus video system installed on the Coast 3D-survey mast and the lighthouse J.C.J. van Speijk. This video system is taking one picture every half hour. Based on this, the flood water line, the beach width, and the location of shoals or sandbanks can theoretically be identified. Further, it is possible to use the information from the video system to monitor the surface evaluations and follow the progress of the shoals and sandbanks. The Argus images provided an interesting insight but did not contribute to the understanding of the possible working mechanism of Ecobeach.

### Sediments and ground water measurements

From August until December 2009 sediment samples were collected and extensively analyzed. These were compared to sediment measurements from a test area in Denmark.

The groundwater flow characteristics and conditions in the test area were mapped down to a depth of 80 m and horizontally from the dunes to the water line. Also, the groundwater flow near the tubes was investigated.

# Recommendations for further studies

*The project Ecobeach led to many useful data and new insights into the coastal processes. Especially, the coarser sand and the fresh water outflow at the ebb water line provide good points to follow up the investigations on the working mechanism behind Ecobeach. BAM wants to continue with Ecobeach and is looking for new locations for the installation. Due to the natural variations of coastlines it is proposed to perform a test with a duration of at least ten years.*

Rijkswaterstaat is welcoming new initiatives with Ecobeach in their area of responsibility and is interested in further research on the working mechanism of Ecobeach. The focus is hereby placed on drawing further conclusions from the tests near Egmond.

Based on the performed tests, BAM and Rijkswaterstaat derived the following list of recommendations for further research:

- Both the development of the contract as well as the technical preparations and realization require thorough planning.
- Define the main points of the project at the beginning. This can for example include the duration of the tests. A potential future project has to have a minimum duration of ten years so that the natural variations can be considered better in the calculations and analyses.

- To ensure good results it is important that if possible, the same people are involved throughout the entire project. Involvement and capacities are crucial for the success of the project.
- In case that large changes occur within one of the parties involved or concerning the project organization, the project needs to be adjusted accordingly.
- BAM as well as Rijkswaterstaat see the financial stimuli (the bonus agreements) in the contract as a positive impulse for an intensive collaboration.

A future innovative cooperation should be realized within the “golden triangle” of scientists and researchers, private companies and the public municipalities. Detailed plans however, are not derived at this moment.

## Ecobeach on a timeline

### May 2005

Letter from BAM to the ministry

### November 2005

Signing of the letter of intent by BAM and Rijkswaterstaat

### October 2006

Signing of the contract

### November 2006

Start of the Ecobeach installation

### December 2006

The first 486 drainage tubes are placed

### February 2007

All 629 drainage tubes are placed; the installation is finished

### September 2008

Scientific workshop

### September 2009

Scientific workshop

### November 2010

Removal of the drainage tubes

### April 2011

Final scientific workshop

### October 2011

Final report from Deltares (not accepted by BAM and Rijkswaterstaat due to outstanding discussions about the interpretation of the results)

### November 2011

Evaluation of the collaboration between BAM, Rijkswaterstaat, and Deltares

## Safety

To ensure that the drainage pipes are installed as intended, during the start of the project it was checked twice a week if they were above the beach level. Each report from beach visitors, the municipality, or the water board was treated immediately. For large events additional precautions checks were performed to prevent any inconvenience. During the project, the monitoring work for the contractor steadily decreased.

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