



Inspectie Verkeer en Waterstaat

# Assessment of primary flood defences in The Netherlands

*National Report on 2006*



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# 1 Safety assessment

The Netherlands has become prosperous due to its favourable position in the delta of several large rivers. But without strong flood defences two-thirds of the country would be under water. Nine million people live in this vulnerable area of the Netherlands where 65% of the gross national product is earned. Monitoring the condition of the flood defences is therefore absolutely vital. The condition of the “primary flood defences” is particularly crucial. They protect the land from water from the sea, the major rivers and from the IJsselmeer and the Markermeer lakes.

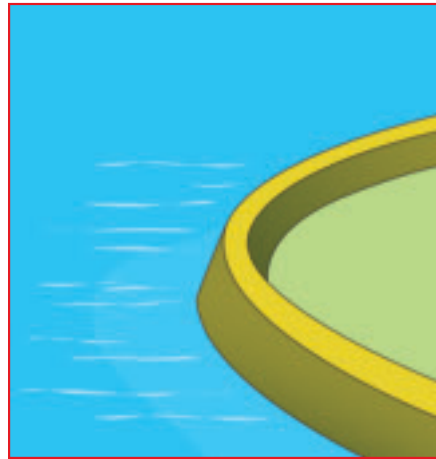
## 1.1 The second assessment of the primary flood defences

The Flood Defences Act requires that those managing the primary flood defences test every five years whether the dikes, dunes and hydraulic structures, such as sluices and closable orifices in a dike, meet the statutory safety requirements.

The assessment of a flood defence can lead to three judgements: the flood defence 'meets' the standard, the flood defence 'does not meet' the standard or because there is insufficient information 'no judgement' can be made.

An assessment of the primary water defences was carried out for the second time in the period 2001-2006. This report summarises and explains the results of the second safety assessment.

The results were also compared with the results of the first assessment.



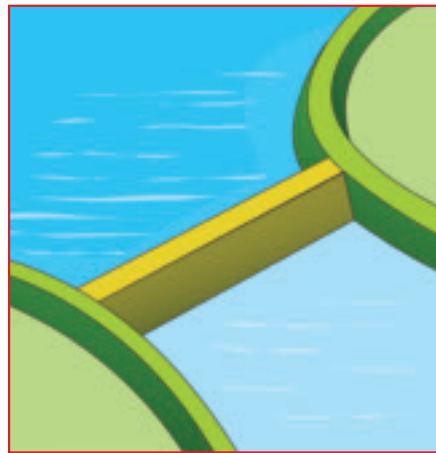
*Flood defence category a*

## 1.2 Primary flood defence categories

The dikes, dunes and hydraulic structures are divided into various categories depending on their position and function.

The assessment covered the primary water defences in categories a, b and c.

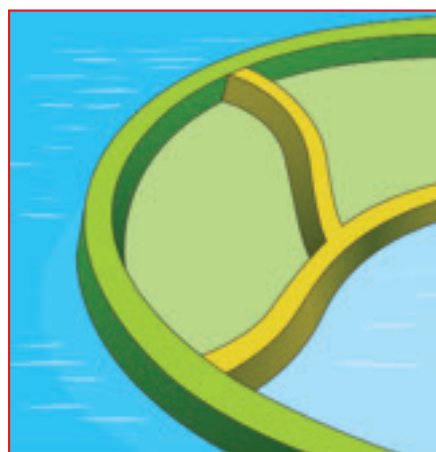
- Flood defences in category a (a defences) include dikes, dunes and hydraulic structures which provide direct protection against the sea, the major rivers, the IJsselmeer or the Markermeer lakes.
- Flood defences in category b (b defences), such as the Afsluitdijk or the Maeslant storm surge barrier, connect flood defences in either category a or c.
- Flood defences in category c (c defences) are defences, which provide indirect protection against flood water. An example of these is the flood defences along the Noordzeekanaal.



*Flood defence category b*

## 1.3 The assessment process

The assessment bodies that manage the primary water defences carried out the assessment. The water boards manage 90% of the primary water defences and the Directorate-General of Public Works and Water Management manages the remaining 10%. These authorities send their assessment reports to the provincial authorities that make an assessment, which is then attached to the reports and submitted to the minister of Transport, Public Works and Water Management. Based on its independent position, the Transport and Water Management Inspectorate evaluates whether the assessment or management has been conducted in accordance with the regulations (this is known as the 'official judgement'). The results are summarised to create



*Flood defence category c*

a national picture and an analysis is provided, together with its findings and conclusions. The Transport and Water Management Inspectorate submits this report to the minister of Transport, Public Works and Water Management.

Based on the summary report, the minister informs parliament about the state of the all the primary flood defences in the country and draws up a programme of improvements, known as the Flood Protection Programme, based on the results.

## 1.4 Assessment

During the assessment the managing authorities check whether the strength of the flood defences meets the statutory requirements. The height and stability of the flood defence contribute to its strength. During the assessment the water boards use the instruments specified by the minister of Transport, Public Works and Water Management, such as the calculation rules laid down in the Safety Assessment Regulations, and data on water levels and waves. Because normative water levels and waves can change over the course of time due to new insights and changes in the natural circumstances, such as average discharges and more storms, this data is revised every five years. Data from the Hydraulic Boundary Conditions 2001 (HR2001) was used or the second assessment of the flood defences.

A different assessment method was used for category c defences than for the category a and category b flood defences.

The minister of Transport, Public Works and Water Management has not laid down any detailed regulations for the assessment of flood defences in this category. The assessment therefore does not give a picture of how reliable these defences are.

During the first assessment in 2001 under the regulations the managing authorities were required to give a description of the physical condition of the c defence in 1996.

During the second assessment it was assessed to what extent the physical condition of the flood defence had changed relative to the first assessment.

From the assessment three different judgements about the flood defences could be made; that it: meets the standard ('meets'), does not meet the standard ('does not meet') or it was not possible to arrive at a judgement ('no judgement'). The standard lays down the prescribed level of protection against flooding. The assessment of 'no judgement' was therefore made when the managing authority, for whatever reason, was unable to gather sufficient data or the set of instruments available was insufficient to be able to fully carry out the assessment.

Each authority was given the opportunity to include its own 'manager's judgement' in addition to the requirements of the Safety Assessment Regulations.



## 1.5 Reaching an official judgement

This report gives the official results of the assessment of the primary flood defences at 1 January 2006, this being the reference date. All the assessment results were discussed with the provincial authorities concerned and they supported the official judgement. To arrive at its final opinion the Inspectorate based its judgement on the following basic principles.

- In arriving at its official judgement the Inspectorate generally adopted the opinion of the managing authorities with regard to flood defences in categories a and b. In a few cases was this opinion not adopted because the managing authority had not provided a sufficiently sound reason as to why the technical requirements had been deviated from.



- Where the physical condition of a category c flood defence had not changed relative to the situation in 1996, it was deemed to 'meet' the standard. Where the managing authority reported 'meets' on the basis of this comparison, this assessment was adopted. Often, for the category c defences, which provide indirect protection and for which no hydraulic boundary conditions have been set, the managing authorities made their assessment on the basis of their own hydraulic boundary conditions. The managers considered that a judgement about the category c defences was necessary to obtain a complete picture. Although the managing authorities' effort to gain as complete an overview as possible of the safety provided by the category c defences is laudable, in these cases the Inspectorate decided to opt for 'no judgement' as the result in its official opinion. This is because an assessment method was used which deviates from that laid down in the Flood Defence Act and which is not uniform throughout the country.
- When the result of applying the rules to a flood defence in category b leads to a 'does not meet' judgement, then a

hinterland study, as it is known, has to be conducted. This involves arriving at a judgement about the dikes, which lie behind this connecting defence. The results of the hinterland study will then determine the judgement for the category b flood defence. There are then two possibilities:

- The hinterland area is surrounded by category a defences. If the hinterland study has not yet been carried out, the category b defence was given a 'no judgement' label. If a hinterland study finds the category a defences behind the water defence to be 'sufficient', the category b defence was also considered to 'meet' the requirements. This also applies where a 'does not meet' judgement was made (see the Afsluitdijk example in §2.3).
- The hinterland area is surrounded by the category c defences. Because central government has not set any hydraulic boundary conditions for the category c defences, no hinterland study can be carried out. In such cases the Inspectorate's judgement for these was 'does not meet' the standard.





## 2 Results of the second assessment

The results of the assessment provide insight into the condition of the primary water defences in the Netherlands. On the basis of this, measures can be taken where necessary for the purpose of either further investigation or to make improvements. In some cases, for example, based on the initial assessment, it has been known for some time that improvements were necessary and measures are already in preparation.

The results of this second assessment further underlined the necessity for these measures.

This applies, for example, to parts of the rivers region and the 'weak links' along the coast.

For a few other flood defences it was only further to this assessment that it became apparent that they do not (or no longer) meet the statutory standards.

## 2.1 Results

The second assessment assessed the height and stability of the flood defences. During the first assessment mainly the height was tested. The comparison between the results of the first and second assessments must be seen in this light.

### Results for defences in categories a and b (providing direct protection)

Figure 1 shows the assessment results for the dikes and dunes, which provide direct protection against flooding from the North Sea, the major rivers and the IJsselmeer and Markermeer lakes (categories a and b). These categories make the largest contribution to flood protection. The Netherlands has 2875 kilometres of such dikes and dunes.

The results for the category a and category b defences on the reference date of 1 January 2006 and compared with the assessment of 2001, can be summarised as follows:

- 1264 km meets the statutory standard. The percentage, which 'meets' the standard, is therefore 44%; in the previous assessment in 2001 this was 40%.
- 680 km does not meet the statutory standard. The percentage, which 'does not meet', is therefore 24%; in the previous assessment this was 19%.
- 931 km was labelled 'no judgement'. The 'no judgement' percentage is now 32% and was 41%.

See also the maps on pages 10 and 11.

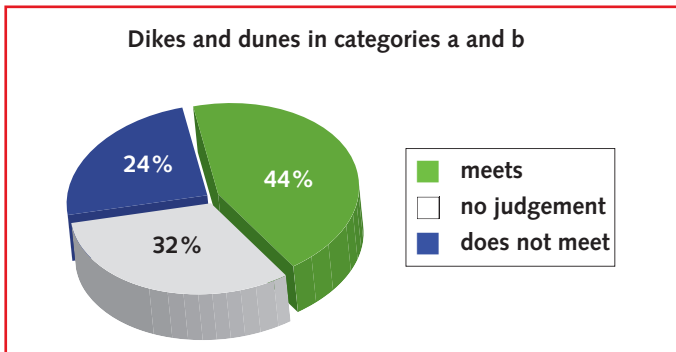


Figure 1. Assessment of primary water defences 2006 – categories a and b (total 2875 km).

### Results for hydraulic structures in categories a and b

The results at the reference date 2006 can be summarised as follows:

- 277 hydraulic structures (29%) were labelled 'meets' the standard;
- 206 hydraulic structures (22%) were labelled 'does not meet' the standard;
- 459 hydraulic structures (49%) were designated as 'no judgement'.

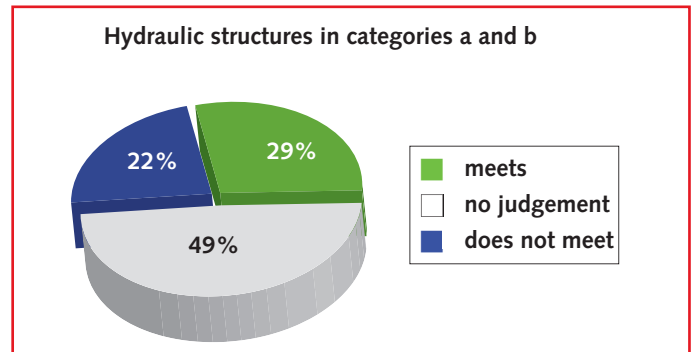




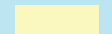

Figure 2. Assessment of primary water defences 2006 – hydraulic structures in categories a and b (total 942 hydraulic structures).

942 hydraulic structures in total were assessed. See figure 2.

The percentage for 'no judgement' is high. For the assessment of a flood defence a wide range of data about its structure is necessary. Unlike in the first assessment, in many cases most of this data is now available but some details are still lacking to be able to reach a final judgement.

## Results of the second safety assessment of the primary water defences, 1 January 2006

### Legend

-  meets the standard
-  no judgement
-  does not meet the standard
-  dike ring area
-  high ground



## Results of the second safety assessment of the primary water defensive hydraulic structures, 1 January 2006

### Legend

- meets the standard
- no judgement
- does not meet the standard

- primary flood defence
- dike ring area
- high ground



### Results for flood defences in category c (provide indirect protection)

Figure 3 shows the assessment results for the flood defences, which provide indirect protection. There are 724 km of c defences in the Netherlands, which represents 20% of the total length of defensive structures.

The results for the c defences on the 2006 reference date, and compared with the assessment of 2001, can be summarised as follows:

- 326 km meet the statutory standard. The percentage which 'meets' the standard is therefore 45%; in the previous assessment in 2001 this was 100%.
- 0 km does not meet the statutory standard. The percentage which 'does not meet' the standard is therefore 0%; in the previous assessment in 2001 this was also 0%.
- 398 km was labelled 'no judgement'. The 'no judgement' percentage is now 55%; and was 0%.

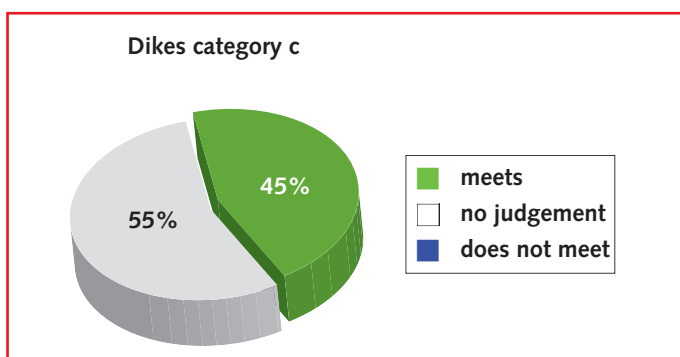


Figure 3. Assessment of primary water defences 2006 – category c (total 724 km).

### Results for hydraulic structures in category c

The results at the reference date 2006 can be summarised as follows:

- 63 hydraulic structures (28%) could be labelled 'meets' the standard;
- 0 hydraulic structures (0%) could be designated as 'does not meet' the standard;

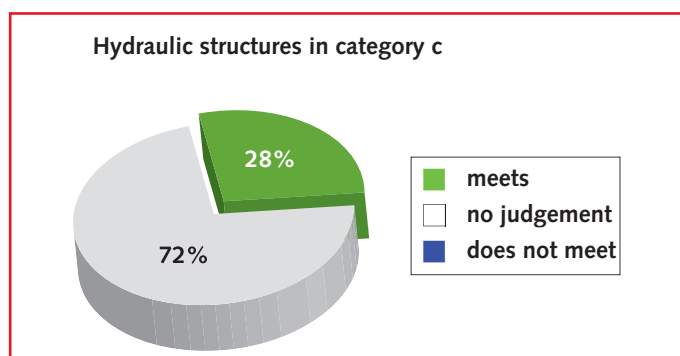


Figure 4. Assessment of primary water defences 2006 – hydraulic structures in category c (total 229 hydraulic structures).

- 166 hydraulic structures (72%) could be labelled 'no judgement';

In total 229 category c hydraulic structures in flood defences were assessed. See figure 4 for the level of safety offered by these flood defences.

In the first assessment the managing authority evaluated all the category c defences (100%), including coastal structures, as 'meets the standard'. In the second assessment, 55% of the category c defences and 72% of the hydraulic structures in the c category were designated as 'no judgement'. The managing authorities have now often tested these defences against their own hydraulic boundary conditions. In these cases the Inspectorate labelled them 'no judgement'. This is because an assessment method was used which deviates from that laid down in the Flood Defences Act.

## 2.2 National picture

The national picture of all the primary water defences provides a general overview of the state of all the primary water defences in the Netherlands. This covers a total length of 3599 kilometres. In the first assessment this was only 3558 kilometres. Due to, among other things, the construction of IJburg, there is now more kilometres of primary flood defences.

The overview comprises two parts, i.e. a national picture of the category a and category b defences and a national picture of the category c defences. The reasons for this are:

- The assessment results for flood defences in categories a and b cannot be added to those of category c for the purposes of the assessment. This is because the category a and category b flood defences were assessed using a different method and against the hydraulic boundary conditions while there are no detailed assessment regulations and hydraulic boundary conditions for the category c defences.
- The contribution made by the category c defences to the national picture is particularly difficult to assess, because more than half the category c defences were not tested in accordance with the prescribed method

### National picture of category a + category b flood defences

The number of flood defences labelled 'no judgement' declined by 9% in the assessment period. Nevertheless for 32% of the flood defences it is still not known whether they are adequate or not. During the assessment period a number of improvements were made. These included more stone revetments and improvements further to the first assessment. Despite this, the percentage of inadequate flood defences has risen from 19% to 24%. During the assessment period, the managing authorities were able to make more progress with the assessment. The percentage of flood defences, which meet the standard, has risen from 40 to 44%. The high percentage of hydraulic structures about which no judgement

can be made can be explained mainly by the lack of data on historical hydraulic structures in particular. Obtaining this information is often very complex.

### National picture of the category c flood defences

The regulations for the category c flood defences does not produce a realistic picture. During the first assessment in 2001 the standard was met by simply providing a description of the physical condition of the category c flood defence. In the second assessment the standard could only be met by establishing that there had been no change in the physical condition of the flood defence. Many of the managing authorities found this form of testing unsatisfactory. Therefore they decided to draw up and use hydraulic boundary conditions tailored to their own situation. 55% of the category c flood defences were tested in this non-standard manner. The Inspectorate therefore had to reject the judgement arrived at in this way, which offered no national uniformity, and designated the assessment as 'no judgement'.

## 2.3 Some special situations

*In the following cases the assessment judgement was arrived at in a different way than normal.*

### Coastal Weak Links

In the first National Assessment Report all the primary flood defences along the coast were deemed to 'meet' the standard. The hydraulic boundary conditions used for the second assessment of the coast matches those, which were used to undertake the first assessment. While the second assessment was being carried out, a better understanding was gained in 2003 with regard to heavier wave loads. In close consultation with the managers, provincial authorities and central government, the consequences of this were determined with the aid of the managing authorities' own assessments. From this it became clear that a number of sites along the North Sea coast would not be able to withstand these heavier loads. This resulted in a list of 'weak links'. First impressions indicate that the estimates for wave load calculated in 2003 closely match those in the new 2006 hydraulic boundary conditions. These developments and the fact that for the rest of the coast no manifestly unsafe areas were encountered, the Inspectorate decided to adopt the opinions of the managing authorities as arrived at in 2003 for the weak links (including for the seaside resorts Zandvoort, Katwijk, Egmond and Bergen) as the assessment result. The Waddenzee, the Oosterschelde and Westerschelde were not included in the opinion of the managing authorities in 2003, because the results of the wave model used were not deemed reliable here.

### Room for the Rivers

Since the floods of 1993 and 1995 it is well known that the normative discharge rates of the Rhine and the Meuse rivers are

higher than had previously been assumed. The hydraulic boundary conditions based on these discharge rates have been laid down in HR2001 for the present assessment round. It is expected that further to the measures taken to provide more space for the rivers under the Room for the Rivers project will mean that the normative water levels in 2015 will again be the same as the normative water levels in 1996. Therefore it has been laid down in the Safety Assessment Regulations for the rivers region that following the assessment with the HR2001, the HR1996 should be used in future assessments. In this way the effect of the river widening measures can be taken into account in the assessment judgement. Approximately half the managing authorities have done this, so that in these cases the results and the figures presented by these authorities anticipate the situation in 2015 after the river enlarging measures have been implemented.

*Further to the completion of the assessment report, some connecting flood defences will be receiving some extra attention. The results of this assessment are briefly set out below.*

### The Maeslant storm surge barrier

In the design of the Maeslant storm surge barrier the criterion applied was that the probability of failure per closure should be no more than 1:1000. Further to extensive analysis it appears that this requirement is not met. This means that higher water levels can occur behind the Maeslant storm surge barrier. The Safety Assessment Regulations prescribe that the managing authority must undertake a hinterland study if a flood defence in category b, which the Maeslant storm surge barrier belongs to, 'does not meet' the standard. This study must show what the consequences of the greater probability of failure would be for all the primary flood defences affected by it. The hinterland study for the Maeslant storm surge barrier is currently being carried out and is expected to be completed in the autumn of 2006. The Maeslant storm surge barrier was therefore designated as 'no judgement'. The managing authority has already taken advance measures to make the probability of failure as small as possible.

### Afsluitdijk

The almost 75-year-old Afsluitdijk 'does not meet' the standard. The dike is not high enough and the grass cover on the crown and the inner slope is insufficiently able to withstand erosion. The sluices in the Afsluitdijk no longer meet the standard because they have insufficient height and stability. If the Afsluitdijk fails the water level in the IJsselmeer lake could rise by several decimetres. Following this discovery the managing authority conducted a hinterland study to investigate the consequences and how the primary water defences around the IJsselmeer would be affected by these higher water levels. The conclusion of this study was that if the Afsluitdijk was to fail these flood defences would not meet the set standards. The final judgement for the Afsluitdijk was therefore 'does not meet' the set standard. The managing authority will be taking steps to reduce the probability of failure.



## 3 Judgement, conclusions and recommendations

The assessment of flood defences is a large and complex job. The technical testing procedures, the gathering of data and the process leading up to the final judgement are all still in development. The experience that has been gained during the second assessment provides the opportunity to be able to improve the quality of the third assessment. The roles of the managing authorities, the provincial authorities and central government will be discussed in the sections below. The Inspectorate has also made some recommendations to improve the third assessment.



### 3.1 The role of the managing authority

The managing authorities put in a great deal of effort during the period of the last assessment, as a result of which we have a considerably better understanding of the flood defences. The Inspectorate has checked the quality of the assessment reports. As part of this, all the reports were examined and it was checked whether the test results were arrived at in the correct way. This examination was carried out in more depth for 70 randomly selected reports. In none of these cases did the Inspectorate reach a different judgement than that of the managing authority. The assessment reports were generally found to be of good quality and thoroughly prepared.

The managers found the renewed interest in the flood defences to be very positive. The collection, updating and validation of the data required for the assessment however require a lot of time and manpower. The second assessment may be seen as more complete than the first because this time the height and stability of the flood defences was included in the assessment. In the first assessment it was often only possible to make an assessment in terms of the height and an estimate was made in relation to the rest (manager's judgement).

Sometimes the managing authority did not have sufficient time to collect the missing information or it turned out not to be possible to take into account the new Safety Assessment Regulations which were only published in January 2004.

The Inspectorate would like to emphasise that the managing authorities need to have the information, which they need for the next assessment ready in good time.

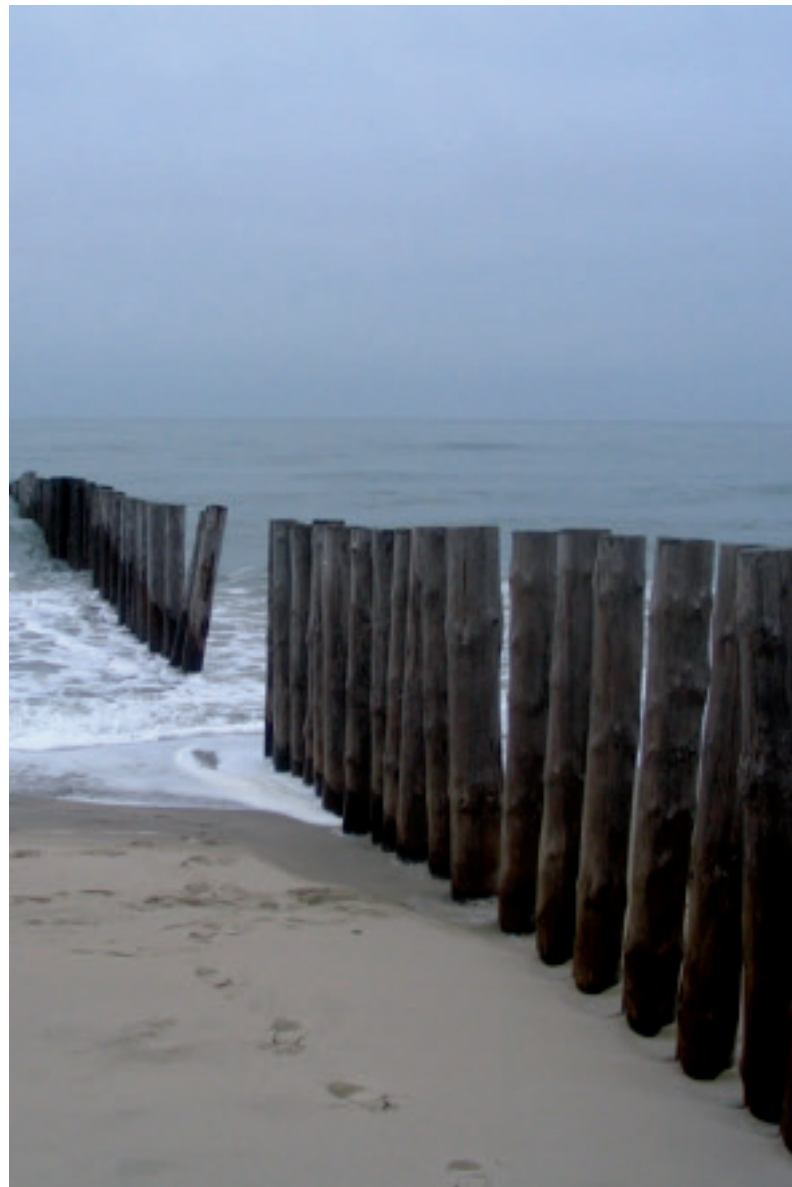
### 3.2 The role of the provincial authorities

All the provinces had a coordinating role in the planning of the assessments.

However, the provincial authorities performed their supervisory role in the assessment process in different ways. Some provinces adopted an arm's length approach. Others have a great deal of knowledge and capacity available to be able to follow and evaluate the assessments carried out by the managers. Some provincial authorities drew up a complete summary report of the assessment results with their own opinion.

In general, it may be said that the managing authorities clearly had more knowledge and experience in this second assessment. As a result most of the provincial authorities were less closely involved in the assessments than during the first round of assessments.

The Inspectorate holds the view that the role of the provincial authorities varied too widely. Therefore the Inspectorate would like to recommend a more uniform approach to the testing process on the part of the provincial authorities. This will benefit the transparency of the process of arriving at the assessment results and help to improve their uniformity. The Inspectorate considers such a uniform approach to be an important part of the assessment framework, which it will use in the third assessment round to arrive at a balanced final judgement, not just about the results of the assessment as such, but also about the way in which the assessment results were arrived at.



### 3.3 The role of central government

#### Improvements to the assessment regulations

Based on the experience of the managing authorities, it appears that there are still gaps in the assessment regulations. These gaps need to be filled by the Ministry of Transport, Public Works and Water Management in time for the next assessment. An example of such a gap is the regulations for the assessment of grass revetment. Simple and detailed calculation rules for the assessment now often fail to give any clear answers or they are entirely lacking. Another example is the testing of flood defences in built-up urban areas. Testing these involves a lot of effort, because many elements of the structure affect the condition of the flood defence. The managing authorities need a practical method to be able to evaluate the effect of the structures.

#### Hydraulic boundary conditions for the Waddenzee

There are no accurate hydraulic boundary conditions available for the flood defences around the Waddenzee and the Dollard estuary. These will become available from 2011 after the results of the Waddenzee measuring programme have been incorporated. The managers hold the view that until that time the effort which would be required to carry out testing would not be in reasonable proportion to the uncertainty surrounding the present set of instruments. The Inspectorate considers it important that clarity should be provided by the Ministry of Transport, Public Works and Water Management about the way in which the assessment of this flood defence should take place in plenty of time for the third assessment. Simply designating it as a 'no judgement' cannot be viewed as a reasonable option in this case.

#### New insights about the coast

New information concerning waves along the coast was not taken into account during the second assessment. It is recommended that this information be incorporated into the hydraulic boundary conditions for the third assessment.

#### Water defences in category c

The Inspectorate feels that the Ministry of Transport, Public Works and Water Management should set the hydraulic boundary conditions and testing regulations as quickly as possible for c flood defences. The managing authorities can then test the c defences in the third assessment in a way, which actually says something about the reliability of the flood defence.

#### Procedure

It is recommended that before the third assessment the Ministry of Transport, Public Works and Water Management makes clear agreements with the managing authorities about when the ministry will provide regulations and boundary conditions and about when the water boards will supply the results of the assessment to central government.

The Safety Assessment Regulations should ideally be published at the same time as the hydraulic boundary conditions prior to the assessment in question.

### 3.4 Follow up

This second assessment was evaluated in consultation with all the governing authorities involved. This evaluation was concerned with both the procedure of the assessment process and the roles of the parties involved. The Inspectorate will include the recommendations made here in the evaluation.



## Colofon

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