

# Monitoringsplan Ameland subsidence 2006 - 2020

March 2006



Begeleidingscommissie  
Monitoring Bodemdaling  
Ameland

**To be found on [www.waddenzee.nl](http://www.waddenzee.nl)**

2000 Monitoring Report  
2005 Monitoring Report  
2000 and 2005 Summary

2000-2010 Monitoring Plan  
2000 Audit  
Video of public presentation of the report

2006-2020 Monitoring Plan  
2005 Audit

Video and photos  
Management field visits  
Aerial and other photographic material

Other relevant documents

WL Report regarding model calculations for subsidence on Ameland  
and new fields

Environmental Impact Assessment of gas extraction in new fields  
reports and background material

## **2006-2020 Monitoring Plan for land subsidence on Ameland**

### 1.1. Introduction

Subsidence is occurring on Ameland as a result of gas extraction. According to the most recent calculations and insight gained from the fields that have already been drilled, this will amount to approximately 37 cm at the deepest point. The subsidence and possible effects have been monitored since gas extraction commenced in 1986.

The monitoring was developed and is carried out by the Ameland Subsidence Monitoring Supervisory Committee. The original programme started in 1987. It was set up to run for ten years and was extended to 2010. To this end, a new programme was published in 2001 (2000-2010 Ameland Subsidence Monitoring Plan; ISBN 90-76690-11-1). In accordance with this plan, a progress report was published in 2005 and presented and discussed in public (public audit by the University of Groningen, June 2005). In 2005, the decision was made to continue the monitoring until the end of extraction, to convert to a 6-year reporting cycle and to revise the programme as far as necessary.

### 1.2. Why is another new program needed?

Looking back over the 18-year history of the monitoring, it is clear that it is extremely difficult to predict the future in detail and accurately. Forecasted adverse effects did not take place, extreme weather conditions caused the unexpected, more gradual changes came to light and new measurement technologies were developed and applied. Monitoring was shown to be a matter of growing insight and flexible consultation. The programme and structure of the consultation therefore is by nature aimed at a pragmatic, adaptive approach.

Around 1995, a study was commenced into the die-off of sea buckthorn, which led to an entirely new programme. In the same year, a study was commenced into the erosion of the salt marsh edge.

In 2001, as a consequence of this and in accordance with the 2000 audit, the programme was dramatically adjusted in a number of areas. The frequency of some measurements was lowered (levelling, monitoring dunes), while the frequency of other measurements was increased (salt marsh edge measurements). Moreover, the inundation and vegetation mapping of the valleys was included structurally in the study.

A new measurement method was developed and applied for measuring the erosion and sedimentation of sand flats (sediment anchors).

Finally, an exhaustive study was initiated into wading birds: what species now forage within the subsidence bowl

compared to earlier data and to other tidal flats without subsidence?

#### 1.2. Continuation of the monitoring

In 2005, a public report was again published on the continuation of the study and the results of the amended, sometimes new programme. During the presentation of the report on Ameland in 2005, the receiving parties (It Fryske Gea, the Municipality of Ameland and the Nederlandse Aardolie Maatschappij) – in accordance with the recommendation of the committee – agreed to continue the study until the end of the gas extraction.

Subsequently the University of Groningen, similarly to in 2000, was asked to carry out an audit of the outcomes of the study and the programme. The audit was to be carried out by recognised researchers who, needless to say, had no direct ties with either the study or the research institutes involved.

The programme set out here is intended to make the continuation of the study structural for the duration of gas extraction as a consequence of the agreements made on Ameland in 2005. The recommendations of the auditors and the relevant responses of those present have also been incorporated into the programme.

Important changes for the time ahead involve the conversion to a 6-year cycles, the inclusion of a social paragraph, the expansion of measurements on the

mudflats, a depth study into the Engelsmanplaat and Rif sandbanks, an intensification of the vegetation mapping of the low dune valleys (in part as a result of the vegetation reversal of this summer resulting from subsidence) and the renewed study into the possibilities of tracking breeding birds.

#### 1.3. Committee decision

On 31 January 2006, the Committee exhaustively discussed the audit report and approved it. Based in part on this, the programme was set down in outline. The organisational coordination of the study was placed with Stichting Amelander Musea, due in part to the foundation's frequent contact with various area managers and its involvement with other studies in the region.

On 7 March 2006, the Committee discussed the 2005-2020 programme and it was unanimously approved.

Dr J. de Vlas  
(Chair)

## 2. Composition of the Committee and Research Team

### 2.1. The Committee and its mandate.

The first official and reliable prognosis regarding subsidence resulting from gas extraction on Ameland dates from 1985. All the forecasts from before this date are based on rough estimates. Based on the first official prognosis, an environmental impact assessment was drawn up by the Waterloopkundig Laboratorium and the National Research Institute for Nature Management (currently known as **WL | Delft hydraulics** and **Alterra**). The predicted effects would affect morphology, the tidal flats, the food available for birds, regression of the salt marsh vegetation, etc. However, the installation had already been built and had been granted a production permit.

As manager of the area, the Frisian nature conservation association **It Fryske Gea**, found itself confronted with possible serious consequences and it was extremely unhappy about the situation. It requested, by letter, the **Nederlandse Aardolie Maatschappij (NAM)** to accept its responsibilities and to determine the actual consequences of gas extraction by carrying out monitoring.

With a view to the credibility of the structure and outcomes of the study, NAM subsequently turned to the Ministries of Agriculture, Nature and Food Quality (LNV) and Ministry of Transport, Public Works and Water Management (V&W) with the request to set up a supervisory committee. The

Committee was to provide a guarantee of independence and was given the task of monitoring progress and supervising completeness and quality.

The Committee was set up in 1986 and currently consists of the following members.

Institution	Member
Ministry of Transport, Public Works and Water Management (RWS)	J. de Vlas (chairman)
Municipality of Ameland	K. Naaijer W. Bakema
It Fryske Gea	H. de Vries
Ministry of Agriculture, Nature and Food Quality (LNV), Department of Regional Affairs for the northern Netherlands	H. Durenkamp
Nederlandse Aardolie Maatschappij (NAM)	J. Marquenie (secretary)
Province of Fryslan	P. Bot W. Elderhorst M. Engelmoer
Directorate-General for Water Management Noord-Nederland	A. Prakken

The Chairman, formerly employed at the LNV, now works for the National Institute for Coastal and Marine Management (RIKZ) and participates as the independent chairman. The NAM fulfils the role of secretariat. Decisions are made by majority vote and to date have been unanimous.

All the members have their own areas of expertise and this provides a definite added value.

The independence of the Committee is guaranteed in the following manner.

Committee members participate at their own expense and contribute individual expertise. Although the study is funded by the NAM, the Committee steers the research and approves it. The researchers report to the Committee.

Progress is monitored by means of annual Committee meetings and meetings of the Committee with the researchers. In this way, new developments can be anticipated and responded to flexibly. The Chairman and Secretary as well as the entire Committee make regular field visits.

A public reporting is made every 5 years. Since 2000 the report and the programme have been open to public discussion. In 2005 the report was once again defended in public in front of a forum of well-known researchers and others in attendance. The meeting was organised by the University of Groningen (RUG). This procedure guarantees a high degree of independence, transparency and flexibility.

It allows the measurement programme to be amended in a transparent way depending on new insights.

The Committee has the necessary authority and trust can operate decisively. To date this has led to a responsible and efficient use of resources with a positive social response.

## 2.2 The Team of Researchers

The original study was set up and developed by Messrs W. Eysink (WL), N. Dankers, P. Slim and K. Dijkema (Alterra). Needless to say, in those years a great many researchers were involved.

In recent years, the following institutions and persons have been involved:

<b>Institution</b>	<b>Researcher</b>	<b>Type of information</b>
WL   Delft hydraulics	W. Eysink Zheng Bing Wang	Morphology Precipitation, tidal data
Alterra	K. Dijkema P. Slim M. Sanders H. van Dobben	Salt marshes Dune valleys (vegetation) Topography Dunes
Ameland Nature Centre	J. Krol M. Kersten W. Molenaar	Dune valleys, mudflat measurements Birds, mudflat measurements Grazing study
NAM	A. Houtenbosch R. Quadvlieg D. Doornhof G. Wintermans W. Veldwisch G. Ketelaar	Prognoses Levelling Data management Precipitation and groundwater level
RWS	Local staff	Checking levelling Sounding
It Fryske Gea	Local staff	Bird counts
LNV	Local staff	Bird counts

In addition to the researchers, various staff members make an enthusiastic contribution to the study. In this respect, the staff of NAM at the gas extraction location should be mentioned as well as the staff of It Fryske Gea and the Directorate-General for Water Management on Ameland.



Dune valleys and beach area at the west of the gas production site. The replacing species, annual Herbaceous Seablite, is clearly visible (see text)



### **3. Management summary of the study up until 2006**

Since 1986, subsidence has been taking place in and around Ameland-East, as a result of gas extraction. On the instruction of the Ameland Subsidence Monitoring Supervisory Committee, a study has been being conducted into the effects of the subsidence since 1987. The research is being conducted by researchers from WL|Delft hydraulics, Alterra and the Ameland Nature Centre.

In 1994, 2000 and 2005 comprehensive reports were published. In the last 5 years too, much new information has become available:

- the subsidence prognosis was adjusted
- clear signs of the effects of subsidence on the dune valleys were observed
- using new technology, highly accurate data was gathered regarding the dynamics of alluvial deposits and erosion of the mudflats.

The 2000 and 2005 reports are meant to be read in conjunction and have been included on the enclosed CD. The Committee states that the reports are complete and of high quality.

A brief summary of the major results follows below.

#### **Land subsidence**

In 2005 the subsidence bowl had a diameter of 12 km and the deepest point had a depth of approximately 29 cm. The expectation at the time was that the bowl would eventually (in around 2020) have a diameter of about 14 km with the deepest point measuring 34-37 cm. The margin for inaccuracy was approximately 10%. According to the current prognosis, the bowl will be slightly deeper than originally predicted, but the expected final volume is somewhat less (14 million m<sup>3</sup> instead of 18 million m<sup>3</sup>).

Early in 2006, the NAM announced a new model that had been adjusted to the most recent measurements in the field. The new model was largely underpinned by completely new measurements that had been carried out at measuring stations in the middle of the mudflats. Adjustments of the model to the new measurements will probably deliver a bowl with a smaller diameter (and volume). The Committee is awaiting official confirmation from the NAM.

In the North Sea, on the mudflats and the salt marshes compensation occurs through accretion and sand transport. The subsidence can therefore only be observed on Ameland itself.

#### **The size of Ameland**

The most easterly part of Ameland by its nature undergoes periods of growth interspersed with periods of reduction. This is due to the natural variation in the channel systems to

the east of Ameland. Up until 2005, Ameland had been growing. The expectation is that from now on Ameland will again become shorter. This reversal has arrived somewhat early than was originally forecast. However, it is not considered likely that the subsidence has had a significant effect on this.

#### **The lie of the sand flats**

There have been no changes in the lie of the sand flats that indicate the influence of subsidence. By applying a new measurement method, accurate data have become available regarding the accretion and erosion of the flats. Taken on the average, accretion was greater than subsidence. This was also measured on the sand flats to the north of Paezemerlannen. The measurements were in complete accordance with the data from the Directorate-General for Water Management. This means that no sand flats have disappeared and that the foraging time of wading birds is not shortened.

#### **The birds**

There have been no indications that the subsidence could have an adverse effect on the wading bird population. In respect of the mudflats to the south of west-Ameland (where there is no subsidence) several species made progress and others suffered reversals. The changes could be explained in part by the impact of shellfish fishing on the mussel banks

#### **The salt marshes**

The salt marshes of Ameland now appear to be well able to resist subsidence. Sufficient compensation by sedimentation of sand and silt that is transported by the tidal currents is observed close to the salt marsh edges and along the salt marsh channels; elsewhere the sedimentation is not enough to directly compensate for the subsidence. The plant growth on the salt marshes appears all but unchanged by the subsidence even in areas with limited sedimentation of clay. Due to the importance of the salt marshes for plant and birdlife any developments are being closely tracked.

#### **Salt marsh erosion**

Along a 1.5 km stretch to the south of the Oerd, salt marsh erosion takes place. This means that the area that is home to rare plants is becoming increasingly smaller. This erosion had already begun before there was any sign of subsidence and has not accelerated since the subsidence began. In all likelihood, this is an autonomous process such as took place on Terschelling near the Grië until a bank protection was built. On the other hand, along a 1.5 km stretch to the south of the Hon the salt marsh is growing.

**The dry dunes**

The dry dunes and the plant life present there have shown no observable effects from the subsidence.

**The dune valleys**

The dune valleys in the subsidence area are definitely more wet and several valleys are more frequently flooded by seawater. The first indication that changes were taking place there was seen in 1994, when, in a number of valleys, Sea Buckthorn bushes, Elders and Hawthorns began to die. This was due in part to an extremely wet winter in which Hawthorns died on other islands as well. The observations provided a reason for a new study from which the conclusion was that subsidence had also played a part. The valleys to the west of the NAM location clearly remain under water for a longer time (for 4 months instead of 2 weeks) than in places where there is no subsidence. In the summer of 2005, the vegetation in the wettest areas died off completely. The annual Herbaceous Seablite sprang up in replacement. It can be expected that the plant growth here will undergo further changes.

**Continuation of the study**

Since 2007, new gas fields are being produced along the mainland coast. The expected subsidence overlaps slightly with the subsidence of the Ameland reservoirs. The Committee will include the information concerning the impact of extraction from the new fields in its evaluations, in so far as these have an influence on the conclusions regarding gas extraction on Ameland. This explicitly

includes the development of flats and channels in the surrounding Borndiep, Pinkegat and Zoutkamperlaag tidal basins. The accumulation with other activities (shell extraction, new gas extraction) will be taken into account when necessary.

**Symposium and audit**

The Supervisory Committee appreciates that the data gathered is generally available and that (scientific) debate about the study and the conclusions arising from it is possible. For this reason, it is with pleasure that the announcement can be made that the results of this subsidence study were presented on July 7, 2005 at a symposium that was open to the public at the University of Groningen. This symposium also served as an audit in which several leading experts, who were not involved in the research, assessed the quality of the study and the conclusions and gave advice about how to continue.

#### **4. Public audit**

The most recent audit was carried out at the University of Groningen (RUG) on July 7, 2006 and was led by Prof. Dr J. Bakker. The Chairman of the day was Mr R. Cazemier (at that time Chairman of Wadden Sea Council).

Important new outcomes were the inclusion of a social paragraph in the next report, an extended study into the sand balance around Engelsmanplaat and Rif sandbanks, recognition of the sediment anchors and of the new measurement set up in 2000 in the dune valleys. The birds study was also recognised.

A report and the points for action can be found on the website [www.waddenzee.nl](http://www.waddenzee.nl)

## 5. 2006-2020 Multi-year monitoring programme

An important outcome of the audit and public discussion was the conversion of the programme into a 6-year cycle. This was mainly due to the desire for coordination with the sounding programme of the Directorate-General for Water Management. Looked at in a logical order, the programme is as follows:

### 5.1. Land subsidence prognosis and measurements

NAM has been working on a new reservoir model. The new prognosis is more in line with the actual measurements. Moreover, for the first time since gas extraction began, measurements were carried out on the sand flats. To this end, a network of tide gauge benchmarks was measured by the Directorate-General for Water Management. In the years ahead, this network on the mudflats will be further refined and measured more often.

### 5.2. Morphology of the island and tidal flats

An important comment from the floor during the public audit, concerned the alleged changes to the Engelsmanplaat and Rif sandbanks. The question was whether the subsidence in the Pinkegat played a role in this. In addition, the calculations that were made within the framework of the environmental impact assessment of gas extraction in Lauwersoog-Moddergat, demonstrated that in the

Zoutkamperlaag too, sand starvation occurred. The sand balance around the Engelsmanplaat sandbank and Rif island will be accurately depicted. This study was completed by 2007, and revealed that the subsidence did not affect the sand mass in the Engelsmanplaat-Rif area.

### 5.3. Groundwater, rain, evaporation and floods

These parameters are of particular importance for properly mapping vegetation. Water levels and storms also have a possible impact on the height of the sand flats, the breadth and depth of the channels and the development of mussel banks.

### 5.4. Salt marsh vegetation

The monitoring of the salt marshes will continue with a frequency of 2x a year. In the future, if the central salt marshes have caught up, this frequency can be reduced to once a year or once in two years.

### 5.5. Salt marsh edge along the Oerderduinen

The development of the salt marsh edge and the special vegetation present there will be evaluated on a 6-year basis.

#### 5.6. Wet dune valleys

The programme for the wet dune valleys has worked well and will be continued. However, in the summer of 2005 a noticeable reversal took place among the vegetation. For this reason, the decision was made to increase the frequency of the mapping from once in 3 years to once in 2 years. In addition, a specific programme will be implemented to map protected species and track them for a year. A photographic record will also be implemented.

#### 5.7. Dry dunes vegetation

Monitoring the vegetation of the dry dunes is mainly in the scientific interest and will be continued in a less intensive manner.

#### 5.8. Birds

The birds study was constructive. There appears to be a relationship between the ups and downs of the mussel banks. It is therefore important to keep monitoring both the birds and the development of the mussel banks. Moreover, methods will again be sought for mapping breeding birds.

#### 5.9. Photographic report

The photographic report of the Storm surge gully, the Hon, the salt marsh edge and the valley with Common Hawthorn will be continued. The development of the low-lying dune valley A has been added as a new object.

#### 5.10. Social aspects

Social aspects adds a new element to the report. This mainly involves the social value of the research. For example, the numerous field visits and discussion weekends within the framework of scientific education, internship staff and the usefulness of the research regarding the issues involving rising sea levels.

More than 2000 students and scientific staff visited the research area and took notice of the results. Many participated during weekends. It is the intention to continue this study programme.

Also to be mentioned are two PhD students (University of Groningen) that will be working for the coming 4 years on the definition and characterization of proper reference-areas for dune-valleys and salt marshes.

Their appointment is a follow-up of the audit conclusions of 2005 and fits the social (education) and scientific goals.

## Overview monitoring activities 2006-2020

■ = draw up report  
 ■ = draw up main report  
  = also gather data / carry out field work  
 ■ = gather data / carry out field work

Code	Committee	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Comment
M1	Social context																Or 2008, 2011, etc.?
M2	Social activities																
<b>NAM</b>																	
M3	Land subsidence measurements																
M4	Aerial photographs of mudflats, salt marshes and dunes																images available for researchers
<b>SodM</b>																	
M5	Checking subsidence figures in the measurement plan																
<b>RWS</b>																	
M6	Sounding the Ameland North Sea coast zone																data available for researchers
M7	Sounding up to -20m / +Rif and Engelsmanplaat																data available for researchers
M8	Sounding of the entire Pinkegat flood storage area																data available for researchers
<b>WL</b>																	
M9	Modelling of the North Sea coast and Pinkegat																including RWS M6 data
M10	Detail modelling of Pinkegat / Engelsmanplaat																including RWS M7 data
M11	Modelling of entire Pinkegat flood storage area sediment management																including RWS M8 data
<b>Alterra</b>																	
M12	Salt marsh: vegetation point measurements PQs																
M13	Salt marsh: measurement of alluvial deposits SEB																

Code	Committee	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Comment
M14	Dune valley: vegetation development	Blue	Orange	Blue	Orange	Blue	Green	Blue	Orange	Blue	Orange	Blue	Green	Blue	Orange	Blue	or 2008, 2011 report, etc.?
M15	Dune s: vegetation development		Blue	Orange			Green		Blue	Orange			Green		Blue	Orange	
M12b	Elaboration of vegetation mapping					Orange	Orange			Orange	Orange						
NCA																	
M16	Mudflats: flats sedimentation/erosion height development	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M17	Hon beach plain: take panoramic photos	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M18	Nieuwlandsrijd salt marsh: grazing cattle and geese	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M19	Hon beach plain: breeding places monitoring of specific species / GPS /GIS	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M20	Dune valley: monitoring fen orchids and specific species	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M21	Dune valley: monitoring flooding frequency and water	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
M22	Monitoring measurement tubes in Oerd and Kooiduinen	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.? / or no report and data sent to all researchers for their own processing?
M23	Mudflats: monitoring foraging birds in and around the subsidence area	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	or 2007, 2009 report, etc.?
IFG																	
M24	Hon beach plain: monitoring breeding birds	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Blue	Blue	Diagonal	Compare trend with SOVON / does IFG do this?