WL | delft hydraulics

GENERAL R&D CONSULTANCY

R&D 2002

annual report

R&D 2002
Annual Report

May, 2003

WL | delft hydraulics

Contents

1 Introduction

WL | Delft Hydraulics is an independent institute for research and specialised consultancy on water-related problems. Founded in 1927 and located in the Netherlands, it is involved in projects related to natural or man-made water systems all over the world. Research and development activities range from theoretical analysis to numerical simulation and include experimental investigations as well as field observations. Knowledge thus obtained is used to develop, validate and continuously expand high-quality software systems for internal end-users and external clients alike. Specialised consultancy services are provided to both government and industry.

Core competencies include hydrodynamics, hydrology, morphology, water quality and aquatic ecology. Present day problems require a multi-disciplinary approach, and expertise in supporting disciplines available at WL | Delft Hydraulics include software engineering, experimental techniques, field data analysis and policy support.

Application areas involve inland water systems (rivers, canals, rural and urban waters), marine and coastal systems (harbours, coasts, estuaries) and industrial systems (industrial flows, dredging and offshore technology). Environmental impact assessment and decision support are also provided in these areas.

WL | Delft Hydraulics' strategy aims to achieve an optimal balance between research & development and specialised consultancy work. In this way all aspects related to the full knowledge cycle can be covered: from innovative research to practical applications to the formulation of research requirements, and so on.

Although government-funded R&D constitutes an important component of all research and development activities at WL | Delft Hydraulics - and is in fact the main body of the present annual report - additional R&D projects are acquired and conducted as well.

On a national level, a number of research and development projects involve joint development (the role of "advisor to the advisors") activities in which specialised institutes such as the Ministry of Transport, Public Works and Water Management (notably DWW, RIKZ, RIZA) are involved. In addition, R&D projects are carried out directly for industry. In 2002 participation was continued in several national joint-research programmes (notably Delft Cluster, Netherlands Centre for Coastal Research, Netherlands Centre for River Studies).

Internationally, WL | Delft Hydraulics is successful in acquiring European research projects, with each project lasting a couple of years. Amongst these are projects to develop software for on-line use of models and development of an EU standard of guidelines for flood modelling practice.

Participation in joint (inter)national research programmes invariably requires matching funds from each participant. Hence these projects often form an integral part of the annual R&D programme, while at the same time creating a multiplier effect to achieve the strategic goal of WL | Delft Hydraulics: devoting 50% of its time and effort to research and development. In 2002 40% was achieved.

Research and development at WL | Delft Hydraulics is related to marine systems, inland water systems or industrial systems and involves the use of experimental facilities as well as software systems. Hence, R&D projects have been grouped accordingly in this Annual Report.

The corporate policy at WL | Delft Hydraulics is to increase the accessibility of R&D results by using the Internet for communication and dissemination of reports, publications and software systems. The layout of the Annual Report corresponds to the style of WL | Delft Hydraulics' website, which is naturally updated regularly and contains additional information, such as dynamic animation imagery of R&D results.

A PDF-version of the annual report R&D 2002 is available via the website of WL | Delft Hydraulics at www.wldelft.nl

2 R&D policy and programming

With a view to the Strategic Plan 2001-2004, WL | Delft Hydraulics developed the Annual R&D Programme 2002 in close collaboration with representatives from the Dutch ministries involved: the Ministry of Education, Culture and Science, the Ministry of Transport, Public Works and Water Management, and the Ministry of Economic Affairs. These ministries financed the R&D Programme 2002 for a total amount of 6,5 M•.

The R&D programme was based on external as well as internal considerations. Market developments were monitored and demands for new research or products were identified. Representatives from the Rijkswaterstaat (Ministry of Transport, Public Works and Water Management) participated in a special workshop held in September 2001 to discuss the task- oriented research segment of this ministry's financial contribution. Scientific developments were identified through contacts with universities and technological institutes. Implications for the Annual Research Programme were discussed with the Scientific Advisory Board, which is composed of members from universities, industry and government.

Positioned to act as the bridge between fundamental research and practice, WL | Delft Hydraulics converts new knowledge and model concepts which have been developed at universities into applications, and thus cooperates with both sides: universities and other knowledge organisations and engineering offices.
Part of this cooperation is institutionalised in the Netherlands Centres for Coastal Research and River Studies (NCK, NCR) and Delft Cluster. Various joint research projects conducted with the specialised institutes of Rijkswaterstaat, Delft Cluster projects and projects acquired within the 5th EU Framework Programme continued and some new projects were started. Preparations were made for the next series of projects of the R&D programmes at Delft Cluster (2nd phase) and the EU (6th EU Framework Programme).

Knowledge transfer continues to receive attention. Transparency, accessibility and maintenance of knowledge systems are important aspects into which the possibilities of Intranet and Internet are incorporated. However, the transfer of knowledge necessitates a proper articulation of questions and answers which might demand attention even amongst specialists in the same field. An extra dimension must be added if actors from various parts of society are to be served as well. The translation of their demands and of the results of studies into suitable presentations require skills different from what those with which technically- oriented staffs are normally equipped. WL | Delft Hydraulics puts forth effort in breaking down this barrier together with institutes specialised in communication, environmental aspects, etc.
Two examples of studies conducted in 2002 are enclosed with this Section.

The role of experimental facilities was an important topic of discussion in 2000. In 2001 the Ministry of Transport, Public Works, and Water Management decided to support the use of large facilities for a couple of years, and asked WL | Delft Hydraulics to further implement measures to promote the more frequent use of these facilities. A fundamental solution was sought within the framework of NCR and NCK and in cooperation with institutes under the Ministry of Education, Culture and Science.

WL | Delft Hydraulics' objectives were to obtain a coherent research and development programme, to participate in several joint research programmes (usually requiring matching funds and controlled by external programming bodies) as well as to initiate specific internal projects in order to strengthen its core activities. The Scientific Advisory Board played an important role in achieving this balance.

For further information on specific aspects related to R&D policy and programming please contact Huib.deVriend@WLDelft.nl or Rob.deJong@WLDelft.nl

Scientific Advisory Board

Annual R&D programmes are reviewed by the Scientific Advisory Board at WL | Delft Hydraulics. The Board is composed of external members from academic institutes, engineering consulting firms, industrial organisations and government agencies. Meetings are held regularly during the year, in part to monitor the ongoing programme, and in part to prepare the upcoming one. Thanks to the background of its members, the Board is able to provide valuable input related to external developments which may be relevant for WL | Delft Hydraulics. During the year 2002, the Board met twice and discussed the progress of the R&D projects from 2002 as well as the Annual R&D Programme 2003. The Scientific Advisory Board in the year 2002 was composed of the following members:

ir N.A. Amesz	Director AC&M Consultancy & Management Member of the General Board of ONRI
Prof. dr ir J.A. Battjes	Professor of Fluid Mechanics Delft University of Technology
drs J.W.A. van Enst	Directorate Science and Technology Ministry of Education, Culture and Science
ir A. van der Horst	Director Delta Marine Consultants
ir J.M.J. Leenen	Director STOWA Foundation for Applied Research on Water Management
Prof. dr ir J.D. Nieuwenhuis (chairman)	Professor of Soil Mechanics Utrecht University
ir P.T.H.M. Verhallen	Member of the Board of Directors TAS Group Member of the Board of Directors LWI
ir G.J. Schiereck	Head Staff Bureau Strategy Rijkswaterstaat of Ministry of Transport, Public Works and Water Management

Ir Amesz has retired from the Board as of September 2002. Starting in January of 2003 he was succeeded by prof. ir H. Ligteringen, Director with Royal Haskoning, Professor of Ports and Waterways at Delft University of Technology and Member of ONRI.

Knowledge transfer

- Knowledge in integrated coastal zone management: knowledge transfer: a matter of communication?
- The Water-4-space methodology: using future scenarios to obtain a collective vision generation

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Knowledge in integrated coastal zone management: knowledge transfer: a matter of communication?

Objective

The objective of this research project is to identify criteria (and their determinants) for successful knowledge transfer between researchers/consultants and policy makers/clients.

The area of interest is the interaction between actors with policy-making capabilities, who are involved in policy-making processes to some extent, and actors with research and consulting capabilities, who have connections to a fairly extensive knowledge network. To assess the quality of knowledge transfer, we must focus on the interaction between policy makers and researchers; the policy-making process and the knowledge network are contextual.

To assess the quality of the knowledge transfer between policymaker and researcher/consultant, we assume the following:

1. The policymaker has a knowledge requirement, which we will refer to as a 'question.' This question may be ill-defined and rife with tacit assumptions.
2. The researcher/consultant can supply knowledge, which we will refer to as an 'answer.'
3. The quality of the knowledge transfer may be defined as the extent to which the answer 'fits' the question.
4. The 'fit' will be affected by the interaction process between policymaker and researcher/consultant, and – directly or indirectly – by contextual factors (characteristics of the policy process and the knowledge network, institutional and organisational aspects ...)

Different knowledge transfer situations

A distinction is made between three types of knowledge transfer situations:

1 Consulting situation: A policymaker approaches a researcher/consultant with a specific question, and the researcher/consultant provides an answer, usually in the form of a written document (report).
2 Guideline situation: A group of researchers/consultants with different areas of expertise make a knowledge compound (a handbook with guidelines) that is to be of use to a heterogeneous group of policymakers/clients in their decision-making process.
3 Research-driven situation: A group of researchers from different disciplines generates a complex body of knowledge related to some specific theme (e.g., coastal management) while neither the potential clients for neither this knowledge nor the specific questions they may have are known at the time.

The ambition of the project is to improve the understanding of knowledge transfer in each of these three situations, and to then translate this understanding into practical recommendations for professionals who find themselves in such a situation.

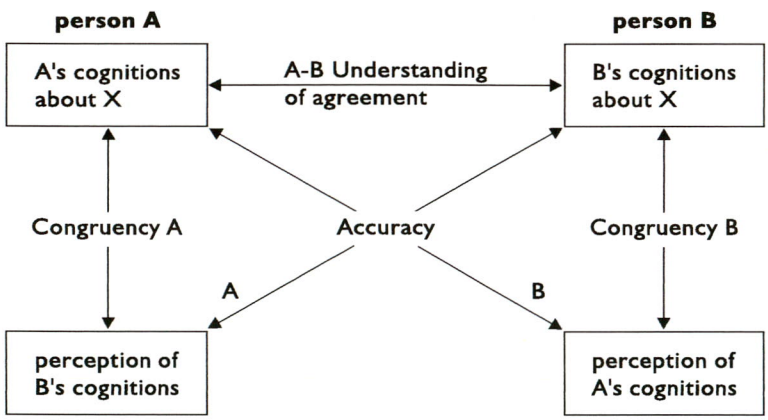
Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Criteria at different levels

To improve knowledge transfer, one must have some measure of knowledge transfer quality. The criteria by which the quality (success) of knowledge transfer may be measured and judged can be illustrated using four categories or levels:

1. Substance: Knowledge transfer is successful if the knowledge that is generated is scientifically sound and provides the answers to the questions as they have been posed by the policymaker.
2. Policy relevance: Knowledge transfer is successful if the knowledge fulfils the actual need of the policymaker, a need which may be different (in scope and detail) from the questions as posed by the policymaker.
3. Policy impact: Knowledge transfer is successful if the knowledge is not only received and understood, but also internalised by the policymaker to the extent that it guides his or her actions in the policy- making process.
4. Field impact: Knowledge transfer is successful if it finds its appropriate application not only by the policymaker who has requested the knowledge (as client), but throughout the policy field. In other words, this occurs once the knowledge has been disseminated and adopted by all stakeholders.

Currently, the project focuses on the first two levels. The aim is to identify, operationalise, and validate a set of criteria for knowledge transfer quality where substance and relevance are concerned.



Communication as co-orientation.

For further information please contact Marcel.Rozemeijer@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

The Water-4-space methodology: using future scenarios to obtain a collective vision generation

Introduction

Imagine that you are responsible for the spatial planning of an area, on either a national, regional or local level. Naturally you are aware that you should initiate and facilitate a dialogue with all stakeholders. Open plan processes are necessary, not only to achieve social acceptance and awareness but also to gain new, surprising insights and views from as many people as possible. Those insights, views and creativity should be mobilised as much as possible to arrive at tailor-made solutions. Yet how does one mobilise those stakeholders? And how can one optimally integrate those insights and views? We have developed a unique role-playing game: the Water-4-space game (W4S-game). The game enrols participants from the very start of a vision-generating process. It stimulates all those involved to solve a challenge presented by spatial planning by mobilising his or her creativity as well as that of others. It challenges participants to freely deal with the problems but also to take advantage of the potential offered by multiple space use, especially those areas that will have to accommodate large volumes of water in the future. In addition the W4S-game increases the awareness that so-called predictions of future development are really nothing more than pretences.

How does the game work

By making and playing the W4S-game, one makes choices and estimations: choices that determine whether water will require a great deal of space or that water will be used to generate space; estimations on important driving forces in our society that influence our spatial planning. How do you think technology, demography or the relation between civilians and the government will develop? What is your vision on these issues? How do you prefer to deal with the broad spectrum of opinions that exist in our society? And which future scenarios will you develop? It is important that the choices to be made for the future are robust enough that an unexpected event will not lead to unnecessary distress. Awareness of the need for a robust design is an important outcome of the game.

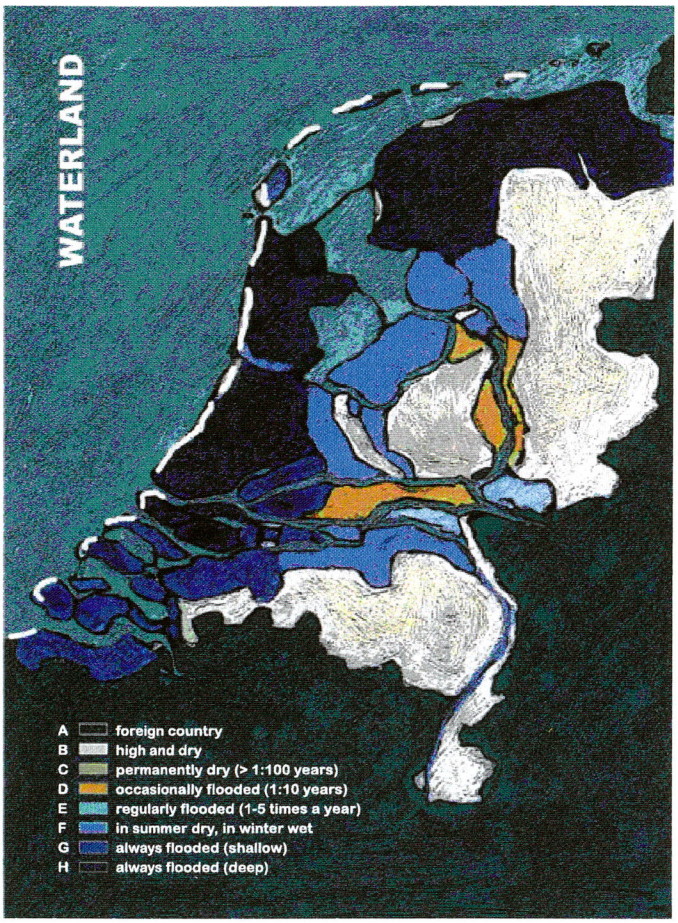
A methodology rather than just a game: stimulating creativity

What we offer is a methodology consisting of both the making and the playing of the game. The actual form of the game is not prescribed but is dependent on the problem and the players. Only the structure is fixed. Stakeholders are challenged to determine the trends and driving forces of their region in order to redesign both the maps and the questionnaire (problem-definition). They are also asked to create the function-units (solution-definition). Using this approach, everybody becomes responsible for defining wishes, needs and solutions. The game can be redesigned for any region, sector or complex social problem.

We have developed the game with a multidisciplinary team. The product, however, is an interdisciplinary product. The team was composed of individuals with very diverse backgrounds, ranging from civil engineering, chemistry, biology, social and cultural sciences to philosophy. The varying views resulted in long and extensive discussions necessary in order to understand one another. This is the true product of a network of people who are able to look over one another's shoulder, to

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

understand one another's arguments and inspiration. Participating institutes: WL | Delft Hydraulics, ICIS - University Maastricht, TU Delft Faculty of Technology, Policy and Management, IVM - Free University, Witteveen & Bos, TU Delft Faculty of Civil Technology and Geosciences.



For further information please contact Marcel.Rozemeijer@wldelft.nl

3 Marine & coastal systems

Marine & Coastal Systems at WL | Delft Hydraulics covers a range from marine and coastal zone management to marine and coastal infrastructure. Areas of expertise include hydrodynamics, hydraulic structures, morphology and environmental processes. Marine and coastal engineering focuses on harbour design, coastal and offshore engineering, including water intake and outlet systems for power and desalination plants. Both research and specialised consultancy projects are carried out for port and coastal authorities, plant operators, oil and gas companies, engineering firms and contractors. All stages of the project life cycle are covered from (pre)feasibility and conceptual design to detailed design and operational aspects.
In the field of marine and coastal zone management, multi-disciplinary research and development is conducted as it relates to the management of estuaries, seas and coastal areas. Special attention is focused on environmental action planning, feasibility studies, environmental impact assessment, fact-finding missions, and specialised technical assistance.

Research and development on marine and coastal systems is being performed in a number of ways and on a wide variety of topics. In addition to theoretical investigations such as the development of new concepts for coastal zone management, experimental research and software development are being used to investigate and simulate processes relevant to marine and coastal infrastructure. Integration of these elements with one another and with data from other sources is a key strategic issue at WL | Delft Hydraulics. Illustrative examples may be found in the particular sections on experimental facilities and software systems.

Several R&D projects were executed under the umbrella of the Netherlands Centre for Coastal Research (NCK) and in co-operation with other institutes. The R&D programme 2002 was focused on various items, grouped into *research on processes* and *development of technology*: Morphological and environmental aspects, such as the relation of riverine and coastal environments and morphology under the influence of changes in the catchment, the overall morphology of casts interrupted by tidal basins influenced by sea-level rise, channel-shoal systems in tidal basins, including effects of sand-mud ratios. The modelling of food webs and 3D modelling of chain effects of relevance for the marine environment, an effort to obtain a better understanding of ecological developments in the North Sea and a general inventory and analysis of a rapidly growing amount of North Sea data.
Modelling technology is an essential part of the knowledge chain, and WL | Delft Hydraulics continuously develops, extends, improves or couples modules to offer better possibilities for more complicated phenomena and more integrated studies. Examples are a new modelling concept for estuaries like the Western Scheldt, the modelling of the transport and fate of oil, or the behaviour of low-frequency waves, data model integration with respect to total suspended matter. Data model integration techniques

were also applied for the assimilation of large volumes of data in tidal modelling and for the construction of synthetic time series in case of insufficient data. The relevance of the latter method was showed with the testcase "Zegerplas" for which high resolution observations from KNMI were available. In respect of improvement of the simulation of transport of sand and fine suspended matter wave-current interaction modelling was further developed. To improve the modelling of waves propagating over local shallow areas a non-hydrostatic free surface-flow modelling concept was applied. The interaction of both waves and currents with near-bed structures was modelled with combined 2D/3D modelling and a tool for the design of breakwaters was improved.

Research on processes

- The Netherlands Centre for Coastal research (NCK)
- Catchment2Coast
- Assessment of the impact of sea-level rise on interrupted coasts
- Feedback mechanisms in channel-shoal formation
- Sand-mud mixtures
- HABES (Harmful Algal Blooms Expert System)
- Insight into the North Sea. An analysis of ecological indicators for the North Sea and problems surrounding their use in policy and management
- 3D modelling of suspended matter, water quality and primary production
- Inventory and analysis of North Sea data

Development of technology

- Transport and fate of oil in the marine environment
- Low-frequency waves in the near shore and in harbours
- Morphological schematisation of the Western Scheldt estuary
- Data Model Integration and Total Suspended Matter; Analysis of SeaWiFS remote-sensing data and DMI methods for assessment of TSM in the North Sea
- Assimilation of along-track TOPEX/POSEIDON altimetry data in a linear tidal model
- Construction of systhetic time series
- The influence of temporal resolution in meteorological forcing for hydrodynamic modelling
- Wave-current interaction
- Non-hydrostatic free-surface flow model
- Waves and currents in the vicinity of near-bed structures
- BREAKWAT 3.0

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

The Netherlands Centre for Coastal Research (NCK)

NCK is helping the Dutch coastal research community to play a prominent role in the international coastal management and research network. It has proven to be a successful platform for mutual interaction and the integration of results from various projects and other research programmes (e.g. the EC Framework Programme, the Delft Cluster and the so-called Generic Coastal Research Programme, funded by Rijkswaterstaat (RIKZ)). As a platform for research co-operation with no research funds of its own, NCK provides an effective way of bringing these programmes together. WL | Delft Hydraulics' own R&D programme facilitates the active participation of WL | Delft Hydraulics expert staff within the NCK programme. The annual NCK Days, held in March 2002, are one example of its platform function. NCK covers the following research themes:

- Seabed and Shelf,
- Beach Barrier Coast,
- Tidal Inlet Systems and Estuaries.
- Sand and Mud,
- Hydrodynamics.

In 2002, seven senior staff members from WL | Delft Hydraulics participated in these themes. Specific research items were related to sand transport and morphology in the surf zone, graded material, sand/mud mixtures, cohesive sediments, support to the construction of a new settling column, application of the Point-Sand model for sand transport by waves and currents across sand ripples, and channel/flat interaction in estuaries and tidal basins. Additionally, special attention was focused on improving the insights into the interaction between morphology and biology with a focus on vegetation and zoobenthos of tidal flats in the Western Scheldt. Field work and experimental tests supported this research on the so-called "biogeomorphology".

Various students and PhDs were coached, new research initiatives were set up, and proposals were submitted for EU-, NWO- and STW funding. Most of the activities were or will be presented at relevant Conferences (ICCE, Coastal Sediments, and AGU). All of these activities also resulted in several joint publications (see the publications list included in this Annual Report).

Inspection of measurement equipment on the Paulinaschor.

Natural sea grass vegetation (Zostera Noltii) in a wave flume of WL | Delft Hydraulics preceding a wave experiment.

For further information please contact Andries.Roelfzema@wldelft.nl

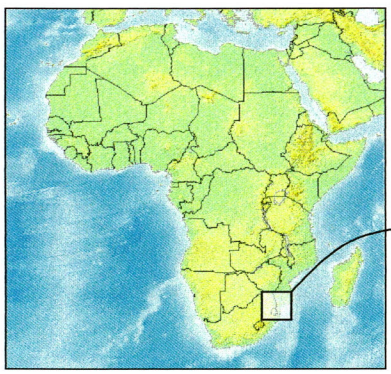
Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Catchment2Coast

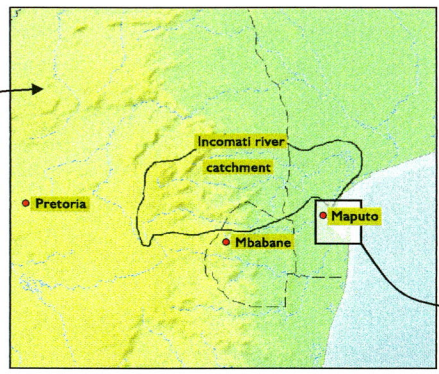
Although the existence of a strong relationship between rivers and coasts is commonly known, the mechanisms that drive the underlying processes still remain unclear to a great extent. Land-use dynamics and climactic change in the catchment can induce profound changes in coastal ecosystems and their natural resources, such as fish and shrimp, yet are difficult to predict. The project Catchment2Coast aims to develop a set of diagnostic and predictive tools with explicit dynamics capabilities with respect to the riverine and coastal environment, validated for the Incomati river basin and the Maputo Bay (Mozambique). These capabilities will promote sustainable resource management on a whole-catchment basis, specifically including the coastal zone.

Catchment2Coast started in October 2002, is funded in part by the EU-INCODEV programme, and will have a duration of 3 years. It is a co-operative research project among 9 different institutes, most of which are established in Southern Africa. The project integrates a number of numerical modules (coastal, river basin and ground water) with the dynamic capability required in order to implement a systematic approach to the functional dependence of coastal systems on river-basin and ground water forcing. The activities focus on a single yet economically important coastal living resource, the shrimp, for which an ecological and resource economics model will be developed to translate the impacts of changes in the river flow into urban and rural livelihoods.

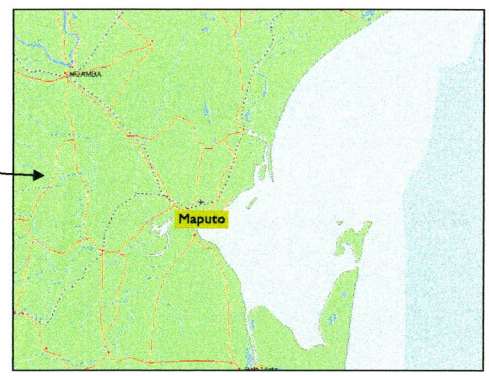
WL | Delft Hydraulics is responsible for the integration of models that are specifically developed for this project. Activities in the year 2002 included participation in the kick-off meeting in October in Maputo (Mozambique), the detailing of work plans and the initial description of the problem analysis and set up of the framework for model integration.



Africa



Incomati River Basin



Maputo Bay

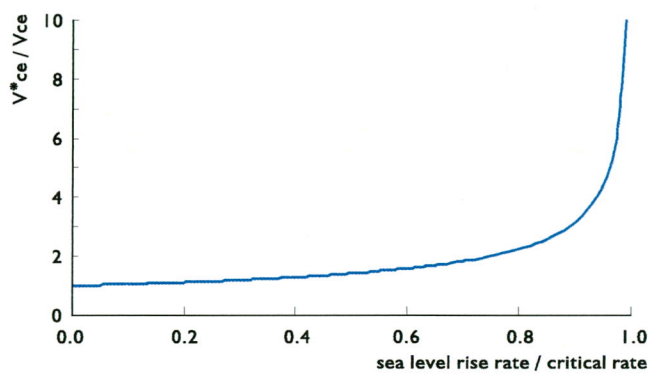
For further information please contact Marcel.Marchand@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Assessment of the impact of sea-level rise on interrupted coasts

Within the framework of the EC-project DINAS-COAST, the impact of climactic change on the coastal zone is assessed on the basis of the worldwide scale. The objective of this project is to develop a tool which can predict the effect of, for example, measures decreasing CO_2-emission on a national level. As a part of this tool, a module is being developed in the current project which predicts the impact of (accelerated) sea-level rise on the morphological development of coasts interrupted by tidal basins such as the Waddenzee. The impact must be expressed in terms of loss of land, loss of valuable ecotope areas such as intertidal flats, and loss of sand which would be required to restore the present situation.

The module has been developed on the basis of the ASMITA (Aggregated Scale Morphological Interaction between a Tidal basin and the Adjacent coast, see Stive et al, 1998) model. This model has already been applied to various tidal inlets in the Dutch Waddenzee in order to study the impact of sea-level rise (Van Goor et al, 2001). The following Figure illustrates the existence of a critical limit of the sea-level rise rate, which, when exceeded, the morphological development is no longer able to follow the sea-level rise in order to establish a dynamic equilibrium. The Figure also shows that accelerated sea-level rise will cause a deepening of the tidal basin, i.e. less intertidal flats and deeper channels.



Dynamic equilibrium (wet) volume under influence of sea-level rise.

The major problem in the present project is that the module must be applicable on a worldwide scale. First, even the already relatively simple ASMITA model requires further simplification since a large number of tidal inlet systems must be simulated for each sea-level rise scenario. Second, the availability of the required data is restricted within the scope of the worldwide scale. Based primarily on the ETOPO2 data set, the general characteristics (size, tidal range etc.) of the important tidal inlet systems have been collected. Empirical relationships were employed to calculate the missing parameters of the simplified ASMITA model (default setting). The module is further set up to provide for the availability of more detailed information for a certain region, in which case the default parameter setting may be replaced by the specific data.

References

Stive, M.J.F., Capobianco, M., Wang, Z.B., Ruol, P. and Buijsman, M.C., 1998. Morphodynamics of a tidal lagoon and the adjacent Coast. In: J. Dronkers and M. Scheffers (eds.), *Physics of estuaries and coastal seas*, Balkema, Rotterdam, pp 397-407.

Goor, M.A. van; Stive, M.J.F.; Wang, Z.B.; and Zitman, T.J., 2001. Influence of Relative Sea Level Rise on Coastal Inlets and Tidal Basins, *Proc. 4th Conference on Coastal Dynamics*, ASCE, Lund, Sweden, 2001, pp. 242-252.

For more information please contact Bert.vdValk@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Feedback mechanisms in channel-shoal formation

The bathymetry of long-stretched tidal basins consists of different kinds of undulations in the seabed (dunes, shoals, etc.) and a system of meandering and braiding channels. Knowledge about the behaviour of these channel-shoal systems is relevant, both for estuarine management as well as scientific purposes. Various studies indicate that the interaction between the local bathymetry and the flow leads to residual flow circulations, which play a role in the development of channels and shoals in a tidal basin.
The main objective of this study is to identify the feedback mechanisms in channel-shoal formation in long-stretched tidal basins. Where the residual flow circulations induced by the bathymetry enhance the growth of the shoals and the deepening of the channels, a positive feedback mechanism exists. The emphasis is put on the investigation of the three-dimensional transversal and longitudinal residual flow circulations. Therefore the residual flow patterns, residual sediment transport patterns and initial sedimentation/erosion patterns in a long-stretched tidal basin are investigated.
The water motion and sediment movement are modelled with the three-dimensional, process-based numerical modelling system Delft3D. A tidal basin with a rectangular geometry is set up (80 km long, 2.5 km wide), with a semi-diurnal tide as boundary condition at the seaward side. In order to carry out 3D calculations the water depth is divided into 8 depth layers. Two states of the development of channels and shoals in the tidal basin are simulated. The first state is an initial state, where the basin consists of channels and shoals that form relatively small, sinusoidal undulations in the seabed. The other state is that where the basin consists of channels and shoals that are more developed and form relatively large, sinusoidal undulations in the seabed.

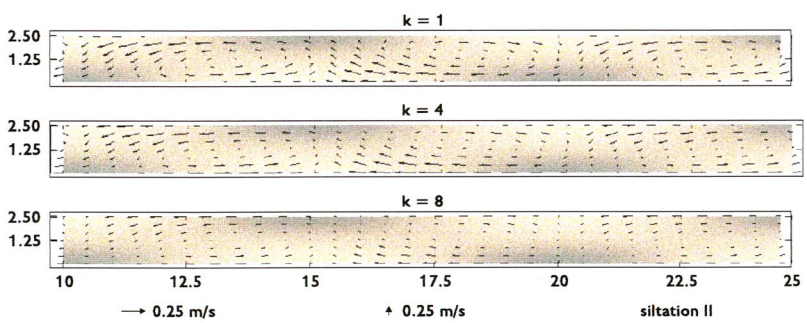


Figure 1.
Top view of residual flow pattern in several depth layers in the area of interest (k = 1 is near water surface, k = 4 is halfway the water depth, k = 8 is near seabed.) A darker colour indicates a deeper section.

Figure 1 shows the longitudinal residual flow circulations that appear in the residual flow pattern in the basin with relatively large undulations in the seabed. The model results clarify the existence of a positive feedback between the local bathymetry and the flow. The longitudinal residual flow circulations form the most important feedback mechanism.
The main conclusion of this study is that although transversal residual flow circulations caused by secondary flow are present in the investigated basins, their magnitude is very small as is their effects on residual sediment transports in cross-channel direction. The presence of secondary flow in cross-channel direction and its magnitude is an indication of the three-dimensional character of the flow and thus an indication of the necessity of carrying out 3D calculations. In future research on the initial development of the morphology of tidal basins with a rectangular geometry with corresponding characteristics to those present in this research, modelling systems making 2DH calculations may be used.

For further information please contact Martijn.Coeveld@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

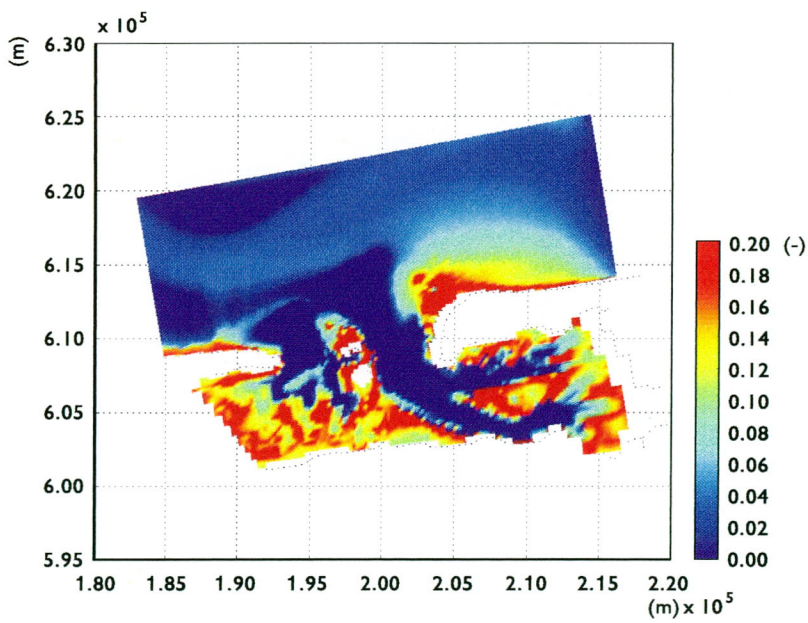
Delft Cluster

Sand-mud mixtures

Natural sediments in rivers, estuaries and seas are composed of various sediment fractions, representing coarse-grained sand and fine-grained mud. The latter consists of sediment particles smaller than 63 mm and exhibits cohesive properties due to the presence of clay minerals and organic material. Variations of the sand-mud ratio in the bed affects the erosive properties and consequently the release of sediment into the water column due to an external forcing.
In 2001 a classification scheme was proposed for the erosion behaviour of sand-mud mixtures and simulations with Delft3D were carried out for a *schematised* tidal basin. Research in 2002 focused on the application of the sand-mud model to the complex morpho-dynamic system of the Friesche Zeegat, taking into account the effect of short waves. The objective of the study was to determine the model's ability to cope with these conditions.

Although a detailed comparison of the results with field data has not yet been made, the study shows that the bed composition of the tidal flats is largely affected by the presence of waves. Moderate waves (up to 1 metre) result in the accumulation of mud on the tidal flats and in a region 1 km. offshore. For wave heights of 2 metres or more, mud only accumulates in a narrow region along the Frysian coast, near the tidal watershed and along the borders of the channels. However, results have been obtained with a simulation period of only two tides and should therefore be considered as indicative. For such a short duration the initial bed composition still has a substantial effect on the model results thus an optimum start-up strategy regarding the bed composition should be investigated.

Calibration of the model is needed to show the capabilities and limitations of the present sand-mud modelling for a natural system. Finally it was found that unrealistically high concentrations can arise, depending on the input parameters (erosion properties of the non-cohesive and cohesive bed) and the start-up procedure (switching on or off of the bottom updating).



For further information please contact M.vanLedden@ct.tudelft.nl or Cees.Kuyper@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

HABES (Harmful Algal Blooms Expert System)

Primary production by phytoplankton forms the basis of most aquatic food webs. However, some phytoplankton species may form blooms whose effects are harmful. Examples of harmful effects include toxicity of shellfish, mass mortality of (shell) fish in aquaculture, and nuisance foam on recreational beaches. During the course of the HABES project (Harmful Algal Blooms Expert System), predictive models were developed for seven harmful algal species in Europe using fuzzy logic. Fuzzy logic is a modelling technique based on knowledge rules instead of the mathematical formulas used by most other modelling techniques. In fuzzy logic models empirical knowledge from measured data and existing knowledge from algae experts may be combined relatively easily. HABES is an EU project in which Rijkswaterstaat and twelve institutes from nine EU countries cooperate.

The objectives of the project were 1) to create more understanding on the interaction between relevant factors, particularly the interaction between physical and biological factors and 2) to make the knowledge on the 7 key species accessible to stakeholders via the models and an internet knowledge base. Stakeholders may then make optimal use of the existing knowledge on the interacting processes thus determining the fate of harmful algal blooms.

In the Dutch pilot project a fuzzy logic model was developed for *Phaeocystis globosa* and *Dinophysis* in the Dutch coastal zone. Not only the presence of the algae species was analysed but also the conditions under which they become harmful. The aim is to predict when *Phaeocystis* blooms are likely to produce foam on Dutch beaches and when *Dinophysis* blooms are likely to cause toxicity in shellfish. Using the resulting models, the effects of climate change, eutrophication and other changes to the Dutch coastal zone may be evaluated. Both existing knowledge from experts, literature, and empirical knowledge were all used. The empirical knowledge was derived from a large dataset of measured data accumulated via data-mining techniques and traditional correlation analysis. The preliminary model results appear rather promising.

Foam on the Dutch beach, probably caused by *Phaeocystis globosa*, observed by the video monitoring system ARGUS.

For further information please contact Anouk.Blauw@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Insight into the North Sea

An analysis of ecological indicators for the North Sea and problems surrounding their use in policy and management

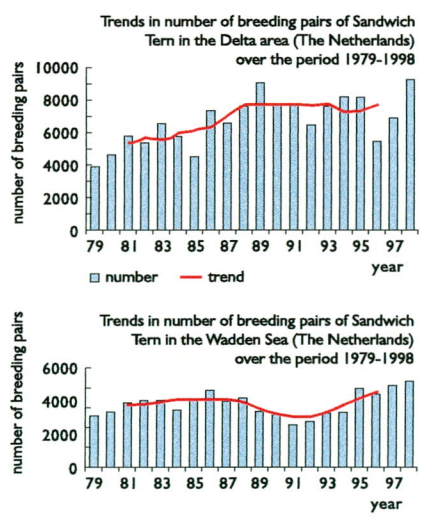
The study involved a review of the development and use of ecological indicators for the North Sea along the coast of the Netherlands. Over the past few decades, various indicator sets were developed for the North Sea to measure its "ecological quality", to evaluate the effectiveness of the North Sea environmental and water policies, and to assist in the prediction of ecological impacts of major infrastructural works and other proposed developments. These include the AMOEBE, Nature Target Types/Ecosystem Targets for the North Sea, GONZ and EcoQO's.

The development of North Sea indicators in the Netherlands appears to have been conducted rather independently at different ministries and institutions, resulting in a duplication of efforts and a lack of clarity for policy-makers and managers regarding which system to use. A series of interviews with various individuals involved in the development and use of ecological indicators for the North Sea revealed a substantial number of problems related to conceptual foundation, feasibility of implementation, response variability and interpretation and utility of the North Sea indicators.

The ecological indicators for the North Sea fail to meet the requirements of their intended end-users, are too complex, and have been poorly communicated. They are not linked to ecosystem functioning, lack policy support due to poor integration between government departments and across government sectors, and lack public support. Moreover, the North Sea ecological indicators have no formal status and lack agreed reference values and quantitative targets. It has also been concluded that ecological indicators alone cannot provide an evaluation of North Sea policy. For this, physical-morphological and socio-economic indicators need to be linked to ecological and economic indicators to allow for a fully-integrated evaluation of the effectiveness of North Sea policy and management. Recent developments suggest further that the Dutch indicators are being overtaken by the international development of indicators within the frameworks of the EU and OSPAR.

Operational indicators, example 2
The Sandwich Tern

- Number of breeding pairs as a measure of the quality of breeding places and food availability
- Common in the Delta and Wadden Sea
- 1991 - 1994: Migration to Belgium



Example of an ecological indicator in the GONZ system: "The Sandwich Tern".

The analysis of the current status of indicators resulted in a list of recommendations which focus on the need for better integration and communication during indicator development, the importance of a clear integrated vision for the North Sea, and the urgent need to lay down objectives and target values in policy documents so that the indicators and their target values obtain a formal status, without which they are essentially redundant. Finally, the report makes some suggestions for further study.

For further information please contact Nicky.Villars@wldelft.nl, Paul.Erftemeijer@wldelft.nl or Henriette.Otter@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

3D modelling of suspended matter, water quality and primary production

The research was dedicated to the "chain of effects" associated with the release and subsequent transport of suspended matter, which leads to an increase in turbidity, a decrease in light penetration and a possible decrease in primary production. This issue is relevant for the effects assessment of many small- and large- scale interventions in the marine environment. Examples are "Flyland (the possible new airport in the North Sea)", and the new Maasvlakte land reclamation in the Rotterdam Harbour area.
The research in 2002 covered several "links" in the chain.

Transport of suspended matter

The first part of the research dealt with the effects of a gradient in the silt concentration pattern on the flow and turbulence patterns. To this end the solutions to the flow equations and the silt transport equation have been coupled online. When the silt concentrations reach values of approximately 0.1 g/l, this coupling leads to a significant change in the predicted silt concentrations (see Figure 1). Although concentrations that high do not occur very often under normal conditions, they do occur frequently during specific storm events. The research indicated that the coupled solutions are more in line with the available field data. Furthermore, the new approach leads to significantly higher predictions of the siltation rates in tidal harbours (see Figure 2). This is an interesting result in view of the fact that classic silt transport models tend to seriously underestimate the siltation rate in the Rotterdam Harbour for example.

Suspended matter, light penetration and algae growth

The effect of suspended matter on the light attenuation in the water column has been investigated by means of an analysis of North Sea field data. This resulted in a better understanding of the parameters which determine the attenuation of light. In particular, the (coarse) material released during dredging works appears to have different attenuation characteristics than the (fine) material which is suspended under regular conditions.
Furthermore, it was demonstrated through modelling that the large variability in the concentration of suspended matter in the field and the connected variability in the light attenuation forms a possible explanation for the large variability in the concentrations of algae (chlorophyll-a) in the Dutch section of the North Sea.
In 2002 research was completed on the topic of 3D modelling of algae growth under light availability constraints. The result was the implementation and the validation of a new light module in Delft3D. This includes a mathematically-consistent combined formulation of the vertical concentration gradients of parameters affecting light attenuation, of the associated vertical gradient of the light intensity, of the vertical migration of algae determined by vertical mixing, of the light conditions "felt" by the algae, and of the resulting growth rate for a range of algae species. The selected approach correctly reproduces the solution of a vertically-averaged model in a 3D model under vertically-mixed conditions.

The nutrient filtering efficiency of an estuary

In 2002 the research into the nutrient-filtering capacity of estuaries was completed. The research confirmed that the retention of nutrients in estuaries such as the Western Scheldt involves, for the most part, nutrients of a marine origin. This has important implications for the expected effectivity of emission reduction strategies.

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

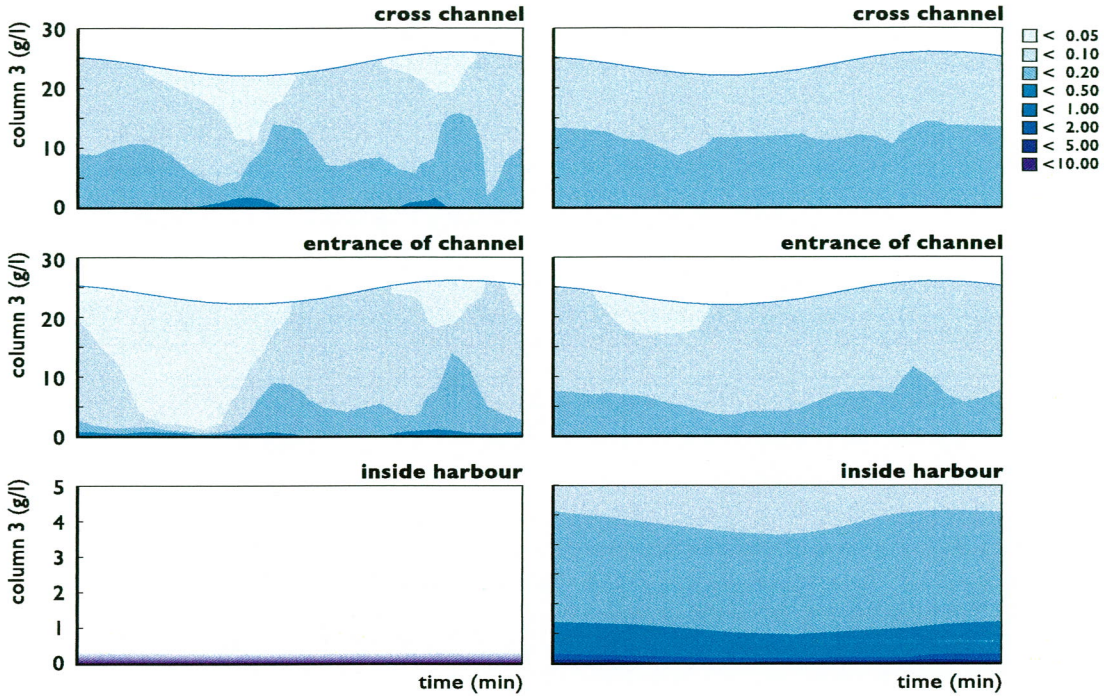


Figure 1.
Sediment concentration as a function of depth (vertical axis) and time (horizontal axis) at three locations (top: in cross channel at sea, middle: entrance of channel and bottom: inside harbour). Left panels: with coupling; right panels: without coupling.

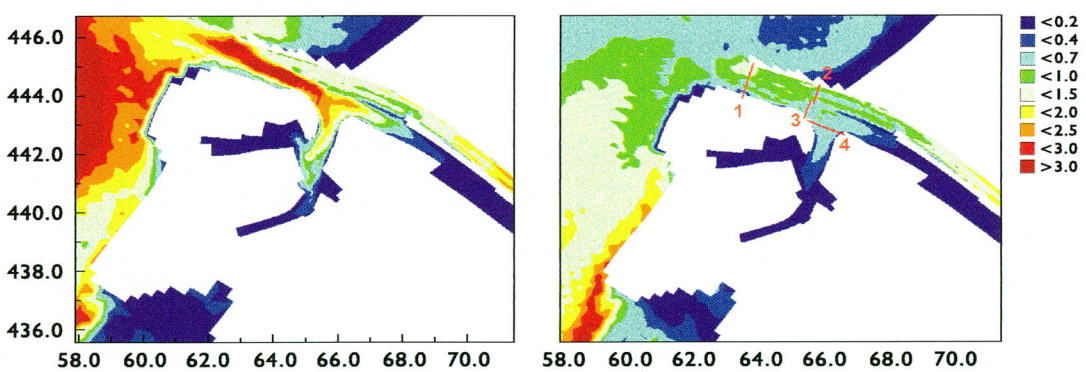


Figure 2.
Computed tide-averaged suspended sediment concentration just above the sea bed. Left panel: with coupling; right panel: without coupling.

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

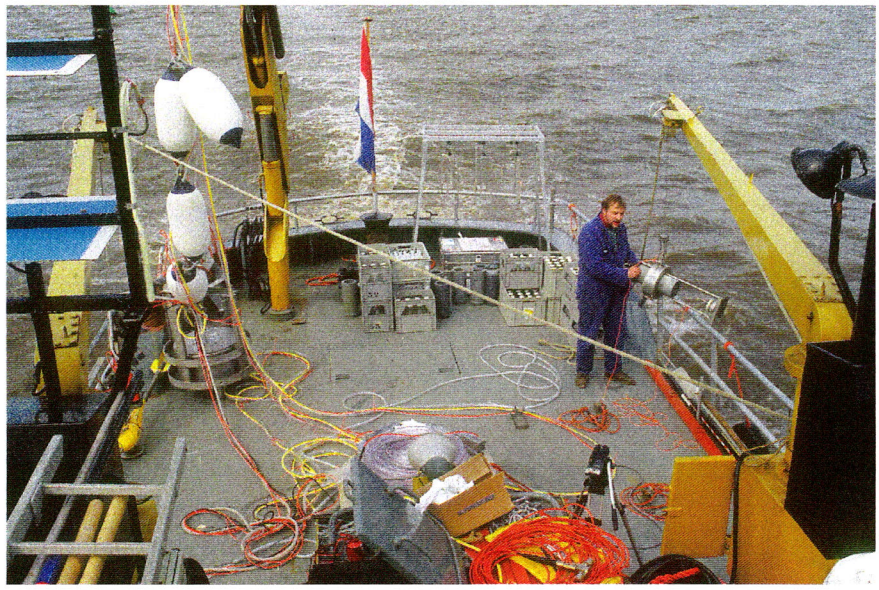
Inventory and Analysis of North Sea Data

In this project, an overview is provided of data sets and databases of relevance to modelling studies of the North Sea. Data sets include not only those available in the Netherlands (e.g. via RWS DONAR system), but also those from other countries. The contents of the data sets are described and documented. Where possible, the different data sets have been acquired and archived on CD-rom for (future) use in North Sea projects. It must be stated however, that the data acquisition process is extremely time-consuming.

One specific activity involved the (re-) establishment of a direct link from WL | Delft Hydraulics to the RWS-Donar database. This direct link allows access to the full DONAR database, not all of which is accessible via the Internet. New procedures for establishing the link and downloading data have been documented and tested. This will allow easy access to all the Netherlands' monitoring data for future studies.

From the available data sets and literature references a data analysis project has been conducted. One of the issues of current attention in (several) North Sea studies (e.g. Flyland) is the concentrations and fluxes of total suspended matter. While much focus has been placed on the Dutch monitoring data for the Dutch coastal zone, this project has allowed for the analysis of other data sources. Specific analysis of a sub-set of the NOWESP data was used to make monthly average concentrations plots, and long-term variations for the Belgian and German coastal regions.

While this project focused on data analysis for the North Sea, the general issues of management of project data, acquisition and analysis of data for modelling purposes and data presentation also came into play, all of which are important for most of the projects at WL | Delft Hydraulics. These issues are of specific relevance for certain study regions where many different projects are conducted over years (e.g. Hong Kong, Venice, and Western Scheldt). Based on experience gained in this project, some recommendations for these issues are provided.



For further information please contact Nicky.Villars@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Transport and fate of oil in the marine environment

Pollution from oil spills has recently become headline news due to the major oil spill in the Atlantic from the sunken oil tanker Prestige off the Spanish coast. This recent event highlights the importance of the research into the improvement of the OIL module of the Delft3D-PART model, conducted by WL | Delft Hydraulics.

The main objectives of the study were:

- to perform a review of the dominant processes that affect the transport and fate of spilled oil in the marine environment and to provide an overview of relevant existing models;
- to conduct an analysis of the OIL module of Delft3D-PART;
- to improve the present implementation of the oil dispersion (entrainment) process description in Delft3D-PART;
- to investigate and then incorporate the emulsification process into the OIL module;
- to test the changes implemented in the OIL module of Delft3D-PART.

After the review and analyses of the existing standard version of the OIL module of Delft3D-PART, several modifications related to viscosity, dispersion, emulsification, evaporation, tracking of particles were implemented.
All variables take the age of the particles into account and are being tracked for each particle individually during a simulation, thus the processes are applied correctly for continuous discharges or several instantaneous discharges occurring at different times.

These changes to the model have been tested extensively, and where possible compared with the oil fate model ADIOS. The focus of the changes was the correct implementation of processes (fate of oil) and not the transport processes, and so the transport (advection and dispersion) of the oil has not been examined further. Within this context, ADIOS is an optimum tool with which to compare the Delft3D-PART(OIL) results, because ADIOS does not include the transport of oil.

The enhanced OIL module of Delft3D-PART was applied to examine hypothetical spills of oil arising from the wreckage of the Prestige oil tanker which sank in November 2002. An example of the results of one of the simulations is shown in Figure 1.

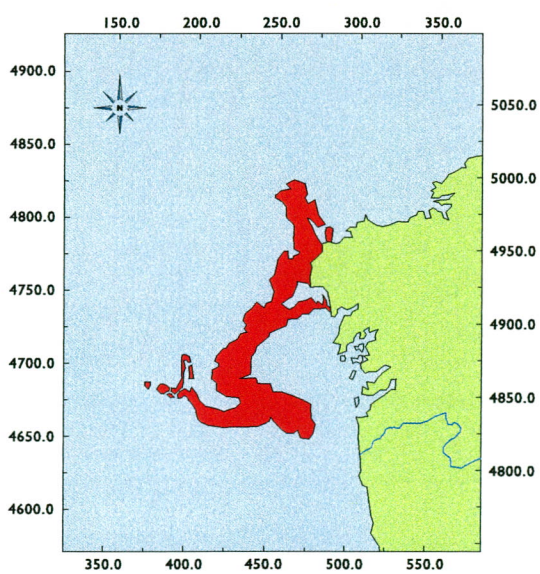


Figure 1. Example of an oil spill simulation.

For further information please contact Tony.Minns@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Low-frequency waves in the nearshore and in harbours

In the framework of the Netherlands Centre for Coastal Research (NCK), studies are being conducted on the behaviour of low-frequency waves (also known as infragravity or long waves) in the nearshore and in harbours.

One project involved the 2DH numerical modelling of the low-frequency wave climate near Duck, NC, USA. The model boundary conditions were generated based on offshore measurements and the model results were validated against measured data, resulting in good agreement for both the integral parameters and the frequency spectra.

Additionally, a data set of forced low-frequency waves measured in a research flume has been analysed to investigate the growth mechanism of incoming and reflected waves (see Figure 1). The results show that the incoming wave shoals much faster than predicted by conservative shoaling, which means that energy must have been transferred to it from the short waves. In addition to the analysis of laboratory data, a theoretical model for the phase delay between the wave groups and the low-frequency waves, which governs the growth of the infragravity waves, has been developed. The wave flume experiments have been simulated with a numerical model "SHORECIRC", which demonstrated good agreement between measurement and numerical results. After validation the model has been used to perform an analysis of the parameters that control the shoaling of the low-frequency waves.

The "SURFBOAT" numerical model has been applied to the case of seiching in two ports: Barber's Point Harbour in Hawaii, USA and Saldanha Bay in South Africa. The model derives its offshore boundary conditions from measurements, and the results show that the fundamental seiching modes in the basins are accurately reproduced. Figure 2 shows the instantaneous surface elevation in and near the harbour. The model has been used to study the effect of mitigating measures in order to reduce seiching and downtime.

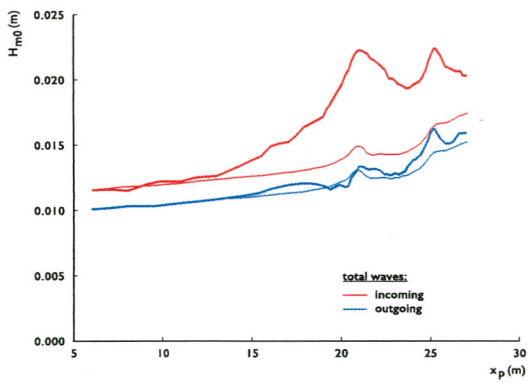


Figure 1. Wave height of incoming low-frequency wave (red) and height of reflected wave (green) versus cross-shore distance. The shoreline is to the right.

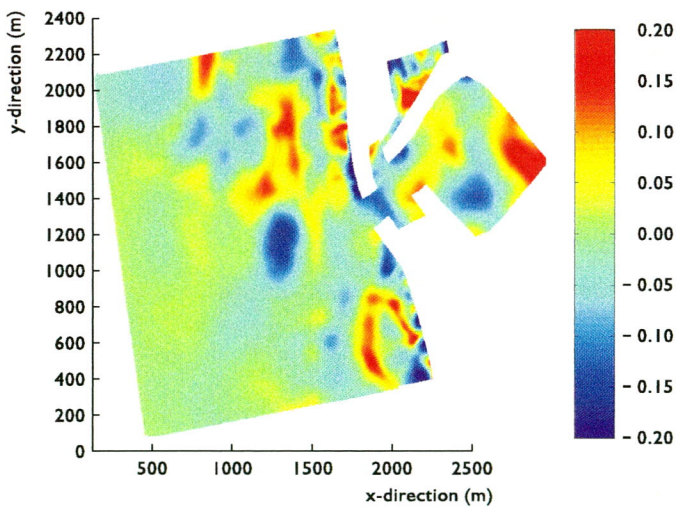
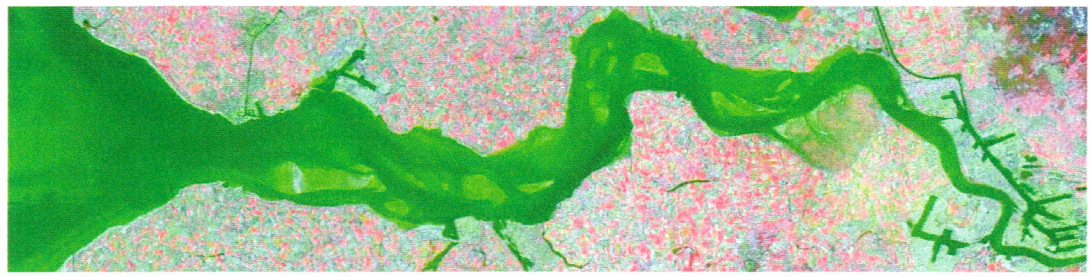


Figure 2. Snapshot of the surface elevation in and near Barber's Point Harbour, Hawaii, USA. The open sea is to the left, the basin(s) are to the right.

For further information please contact Ap.vanDongeren@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

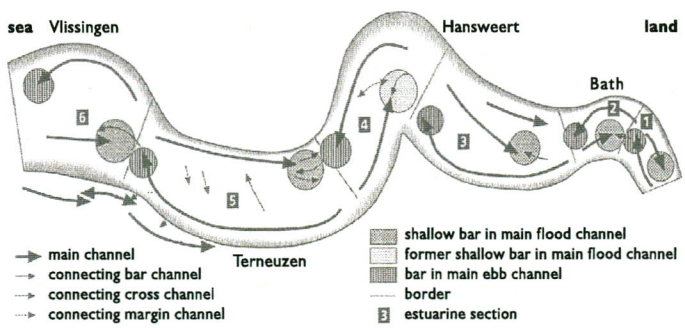
Morphological schematisation of the Western Scheldt estuary

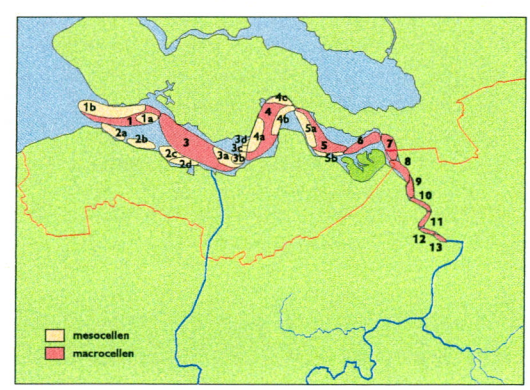


Source: NLR / ESA

As part of the LTV-SE project (Lange Termijn Visie Schelde Estuarium / Long-term view Scheldt Estuary), a new morphological schematisation of the Western Scheldt estuary was developed. The tidal flats and surrounding ebb and flood channels form morphological cells, and the entire multiple channel system was schematised as a chain of these cells. The concept allowed the theoretical assessment of the dumping capacity (of sand) of the channels: if more sediment is dumped, degeneration towards a one-channel system will occur. The cell concept was based on a stability analysis for individual cells and gross sediment transports through the channels.

The objective of the R&D project *Inzicht in watersystemen: Westerschelde* (Insight into water systems: Western Scheldt) was to further verify the assumptions underlying the approach as well as to improve the theoretical basis. The study shows that the dumping capacity is influenced by 1) the ebb or flood dominance of the channel, 2) the autonomous development (degrading or aggrading), 3) the exact dumping location and 4) the sediment exchange between the cells. The latter implies that the chain of cells should be considered integrally rather than individually. Furthermore, the theoretical basis of the approach was expanded to take the flood-ebb circulation into account. The methodology will be made operational in the coming years so that it may be used as a tool for the development and evaluation of new sustainable managerial strategies regarding fairway maintenance and sand mining in the Western Scheldt.





For further information please contact Claire.Jeuken@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Data Model Integration and Total Suspended Matter

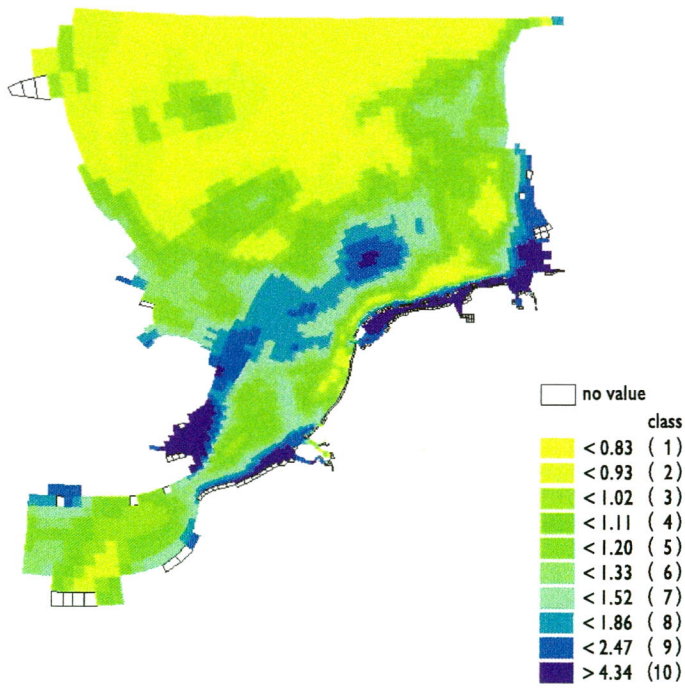
Analysis of SeaWiFS remote sensing data and DMI methods for assessment of TSM in the North Sea

This project is one of several research projects in the area of Data Model Integration (DMI) at WL | Delft Hydraulics. It is a follow-up to previous projects which focused on the use of satellite optical remote sensing data in combination with a dynamic water quality model to study patterns, concentration and transport of Total Suspended Matter (TSM). Previous projects included RESTWAQ, Meetstrategie 2000+, RESTWAQ2, PROMISE RESTWES and RALLY.

The current study focused specifically on the use of SeaWiFS satellite data together with the "ONL-sed" suspended-sediment model for the North Sea. The objectives of this project were: (1) for WL | Delft Hydraulics to expand its experience in and basic understanding of the remote sensing (SeaWiFS) data-acquisition and processing steps for the purpose of improved DMI capabilities and (2) to assess various Goodness-of-Fit techniques for objective comparison of model and remote-sensing data, and (3) to allow a Goodness of Fit routine to become operational for use with SeaWiFS and the "ONL-sed" numerical model.

190 SeaWiFS remote sensing satellite images of the North Sea for the year 1998 were acquired from the Dundee Scotland receiving station. These images were available free of charge under the conditions of a SeaWiFS research data use agreement. The data were processed using the standard SeaWiFS data analysis software (SeaDAS) as well as a specialised software extension for turbid waters (e.g. North Sea) from MUMM in Belgium. The most important processing step is that of 'atmospheric corrections'. The processed data is in units of normalised water leaving radiance (nLw at 555 nm), which is assumed to be directly proportional to the Total Suspended Matter (TSM mg/l) in the water.

The processed satellite data were linked to the "ONL-sed" model by bringing both satellite data and the model to the same geographic coordinate system (i.e. mapping each satellite pixel to the appropriate model grid cell). Monthly averaged products for both satellite data and model results (top model layer) were prepared. In order to compare nLw (intensity) and TSM (concentration, mg/l), both model grid-based data sets were converted into an equal number of 'percentile classes', allowing a Goodness of Fit (GOF) comparison based on 'class number'. A simple GOF based on a cell-by-cell comparison was made operational, and may be applied in the future to the calibration of a yearly "ONL-sed" calculation using remote sensing data, for example. The main objectives of the study have been met. Recommendations for follow-up include further analysis of SeaWiFS data processing steps and further development of Goodness of Fit techniques.



Spatial smoothing method 2: Monthly mean value of water leaving radiance (nLw 555) for August 1998. The mean value for a grid cell is calculated based on the mean and variance of that grid cell and the mean and variance of its neighbouring grid cells.

For further information please contact Nicky.Villars@wldelft.nl

Financed by (a.o.) Ministry of: Economic Affairs

Assimilation of along-track TOPEX/POSEIDON altimetry data in a linear tidal model

For the analysis of the tidal behaviour in large open waters a new data assimilation technique was developed whereby we are able to efficiently assimilate a large volume of data in a linear ocean tide model. The method is based upon representing tidal elevations in a selected ocean domain by a variant of the Helmholtz equations. A cost function is defined as consisting of three parts with different user-defined weight functions or variances. The first step consists of observations in the form of tidal constants from altimetry or altimetry combined with in-situ data being minimised with respect to the model. Next, conditions in the form of differential molecules based upon the Helmholtz differential equation are prescribed, and then boundary conditions are minimised. The choice of weights allows for a data-driven strategy, a dynamics-driven strategy or a combination of the two. In this way, it is possible to monitor the quality of the data, to perform a sensitivity analysis of the model, and to identify and quantify tidal dissipation mechanisms in the area of interest. A conjugate gradient algorithm is used to minimise the cost function.

An application was created for the South China Sea using a model grid of ~ 9500 nodes (including dummy nodes), while the total number of assimilated along-track T/P observation points is ~ 17000. The latter observations are in-phase and are represented by quadrature values of the oceanic tide for 8 major constituents O1, K1, M2, S2, Q1, P1, N2, K2. The results show the known characteristic amplitude and phase patterns with good correspondence in deep water. In addition, the deviation from the linear solution due to various mechanisms (advection, shallow water effects but also internal tides) is quantified by the assimilation method as part of the solution.

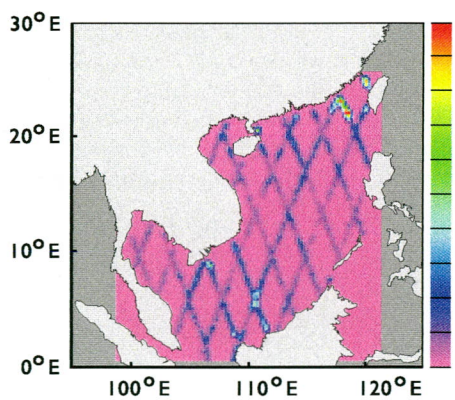


Figure 1 shows the observation residuals of the M2 tide (scale 0 – 10 cm). The TOPEX/POSEIDON ground tracks may be clearly seen. This demonstrates that our model is capable of reproducing the M2 tide to within approximately 2 cm with occasional excursions of up to 10 cm in resonant areas such as in the Taiwan Strait.

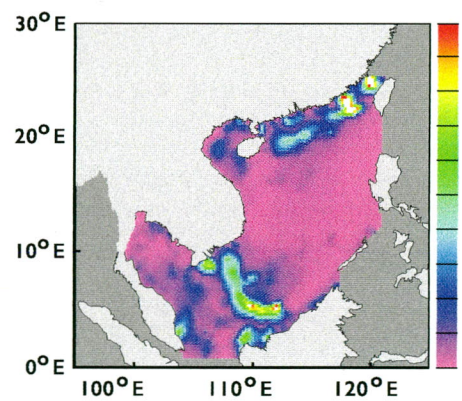


Figure 2 shows the dynamic residuals, or differences from the linear solution for the M2 tide (scale 0.0 – 0.1). The known areas with deviations from linearity automatically emerge: Taiwan Strait, Chinese continental shelf edge, transition zone from deep water to the continental shelf formed by the Gulf of Thailand and the approaches to the Sunda Shelf.

The model provides an efficient way of initial analysis of large open water bodies. Given the combination of data and model dynamics, it offers essentially more than altimetry data per se, while in many applications it may provide a flexible and efficient alternative to setting up and validating a fully non-linear Delft3D model application.

Note: This research was conducted in cooperation with the Delft Institute for Earth Oriented Space Research (DEOS).

For further information please contact Herman.Gerritsen@wldelft.nl

Financed by (a.o.) Ministry of: Economic Affairs

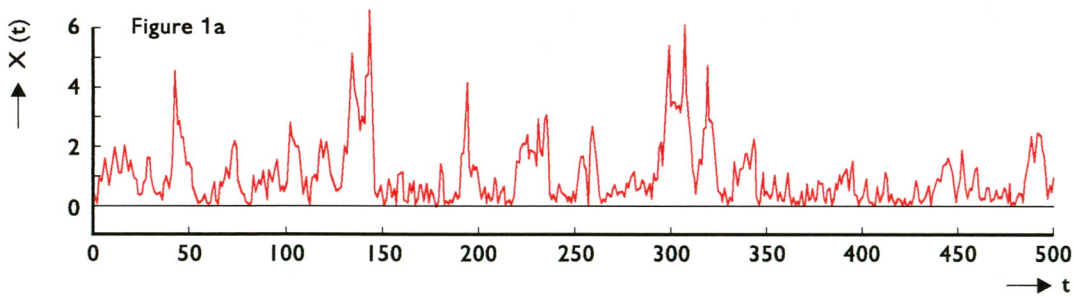
Construction of synthetic time series

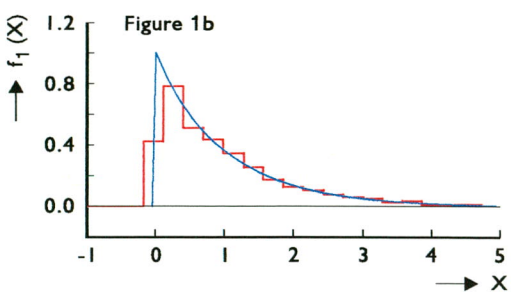
Observed time series are often incomplete due to missing values or gaps. In other cases the series is available for an insufficient time interval, and/or is sampled with a temporal or spatial resolution that is too sparse. Due to this, the derivation of extreme values from a limited record of observations may be complicated or data are lacking a required temporal or spatial resolution. For instance hourly meteorological data lack information on temporal effects whereas data about these effects are needed for design purposes. In general, a "spectral gap" may exist between archived data and required data. For the upgrading of such an incomplete time series, some form of interpolation or extrapolation is often used. In this interpolation the statistical properties of the underlying physical process must be carefully taken into account. This interpolation of an observed time series, and more generally in case of no observations, the construction of a time series that satisfies prescribed statistical properties leads to what we call a *synthetic time series*. Apart from interpolation or extrapolation of observed data, synthetic time series may be valuable for the derivation of statistical properties of random processes (e.g. extreme values), the derivation of inputs for numerical models with an appropriate temporal or spatial resolution, and ensemble-based risk assessment and/or uncertainty analysis.

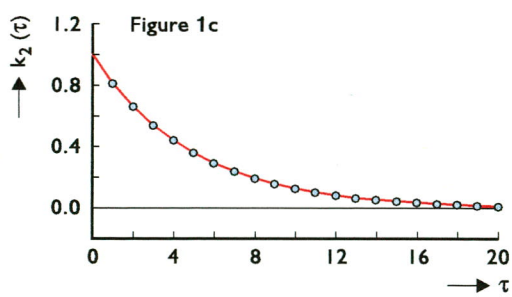
When considering "prescribed statistical properties" of time series, examples such as probability density functions (marginal distributions), second and/or higher order covariance or correlation functions, spectral properties, trends, seasonal variations, or more complex topics such as exceedence times or extreme value statistics all come to mind.

In general it is not possible to find analytical expressions for a time series that satisfies such constraints. Therefore the construction of a synthetic time series was translated here into an optimisation problem which must be solved numerically.

The results of an application are presented in Figure 1. In this application the marginal distribution was prescribed according to the dashed smooth curve in Figure 1b, and the auto-covariance function was prescribed according to the samples in Figure 1c marked by a *. The identified synthetic time series is illustrated in Figure 1a. The marginal distribution and auto-covariance function computed from these samples are shown in Figures 1b and 1c respectively (histogram and solid curve). These estimates from the identified samples closely agree with the a priori prescribed distribution and auto-covariance function. This application was repeated but a subset of observed samples was now prescribed as well. Again a synthetic time series could be constructed that accurately satisfies all of the desired statistics (figures not shown here).







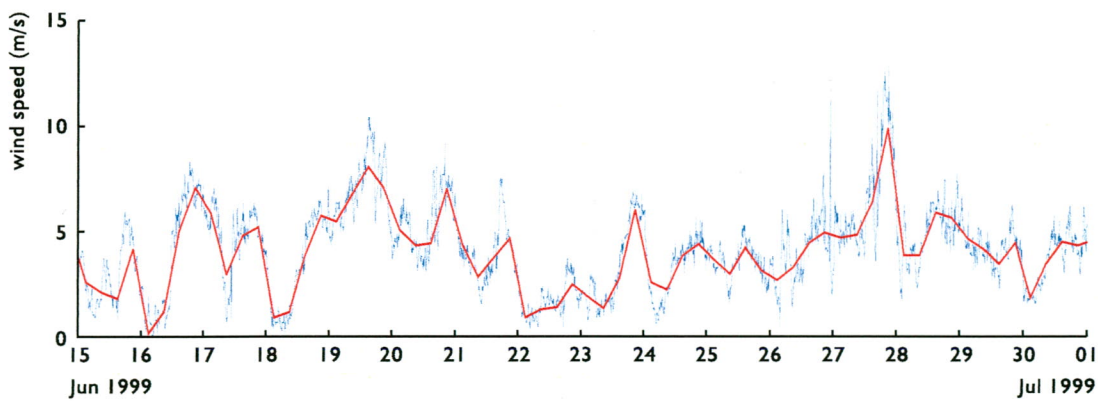
For further information please contact Henk.vdBoogaard@wldelft.nl

Financed by (a.o.) Ministry of: Economic Affairs

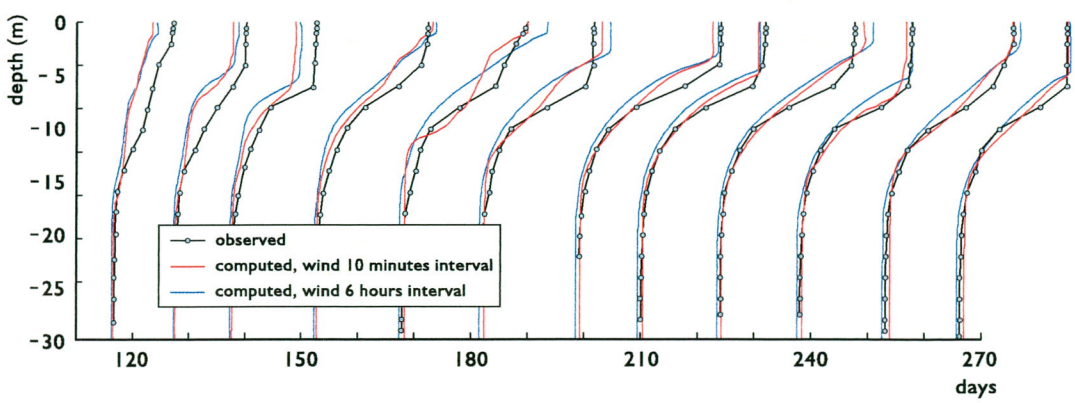
The influence of temporal resolution in meteorological forcing for hydrodynamic modelling. Test case 'Zegerplas.'

Vertical temperature stratification is an important issue in the simulation of water motion and transport patterns in estuaries and lakes. Wind speed, air temperature, relative humidity and cloudiness are prescribed at the water surface to provide proper heat fluxes. Consistent datasets of these parameters can be provided by either the ECMWF or the HIRLAM meteorological models. In previous projects experience demonstrated that the application of data from these models may result in an underestimation of vertical mixing in the hydrodynamic model. This is caused primarily by a poor representation of short period fluctuations in these datasets due to temporal and spatial averaging of the meteo model. The closure of the spectral gap caused by temporal averaging was treated in the DMI project "Construction of synthetic time series." In that project, a formalism was developed that restores the original features in averaged datasets based upon probability densities and correlations. The current project shows the relevance of this newly developed procedure for stratification modelling.

The thermocline development in the Zegerplas (area 1 km^2, depth 30 m) was computed using the Directional Point Model forced by the high resolution (10-minute) wind dataset. Results have been compared with an identical simulation using the dataset averaged at a 6-hour interval. The next figure shows part of the original 10-minute wind dataset and the averaged dataset. Several fluctuations and extreme events do not appear in the latter dataset.



The next figure displays the observed and the simulated vertical temperature profiles from the end of April to the end of October 1999. The top layer thickness tends to be underestimated using the 6-hour averaged forcing. Consequently, top layer temperatures are higher than they were when the high resolution forcing was used.



For further information please contact Herman.Kernkamp@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Wave-current interaction

In order to produce an accurate prediction of the transport of sand (close to the bed) or of suspended material (higher up in the water column) by the combined motion of waves and currents, the effect of wave-current interaction (WCI) must be taken into account. In general, the transport characteristics present in the situation of both waves and currents are significantly different from those without waves.

In future, the total motion in coastal areas might be determined using a non-hydrostatic flow model, which would provide more insight into the wave-induced driving force for the mean motion. However, the required computational time for non-hydrostatic model runs is too long. In this project a 1DV spectral approach, developed by Uittenbogaard (ICCE 2000), was used to include the effect of waves, obtained from a spectral wave model (SWAN, developed at Delft University of Technology) in a hydrostatic tidal flow model (Delft3D-FlOW, developed by WL | Delft Hydraulics).

The solution procedure of the spectral-1DV model was split into an outer loop for the mean-flow equations, and into inner loops for each spectral component of the orbital motions. After the completion of a spectral wave period, the WCI force and other related wave-averaged quantities were updated. These wave-averaged quantities were used for the solution, in the outer loop, of the mean flow vector. Figure 1 and 2 contain the comparative results with experimental measurements obtained by Klopman (1994), who considered both regular and irregular waves on a turbulent current in a laboratory flume.

The spectral-1DV model was implemented as a separate module in Delft3D-FLOW. For every grid point in Delft3D-FLOW, the spectral-1DV produces the two-dimensional, depth-varying, wave-averaged driving force and other wave-related quantities for the mean flow equations.

A first validation exercise was carried out using Klopman's laboratory flume experiments. The results are encouraging. Validation against fully three-dimensional situations requires a huge amount of computational time. Interpolation routines were developed to reduce the computational time. The wave-induced driving force may now be determined on a coarser grid. Furthermore a mask has been developed which determines the regions where wave-current interaction is significant.

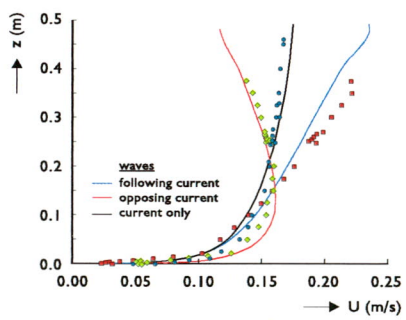


Figure 1.
Comparison between computed (spectral-1DV model of Uittenbogaard) and measured mean horizontal velocity profile.

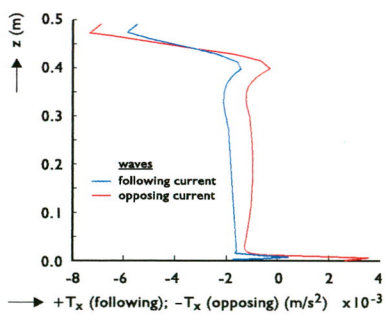


Figure 2.
The simulated WCI force.

References:

Klopman, G.; Laser-Doppler flow measurements for waves following or opposing a current. WL | delft Hydraulics report H840.30, 1994 (feb.), 128 p. + fig., tab., ref..
Uittenbogaard, R.E.; 1DV Simulation of wave-current interaction, Proc. 27th ICCE, 2000, Sydney, paper 60.

For further information please contact Jacco.Groeneweg@wldelft.nl or Rob.Uittenbogaard@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Non-hydrostatic free-surface flow model

Numerical flow models that solve the 3D shallow-water equations are sufficiently accurate for large-scale flow phenomena such as tidal and wind-driven flows in coastal seas, lakes, estuaries, and rivers. The shallow-water approximation assumes that the horizontal length scale is much larger than the vertical scale. For the small-scale flow phenomena occurring in short waves, over a steeply sloped bottom, or in the vicinity of a hydraulic structure, the hydrostatic approximation is no longer valid.

A new vertical approximation of the non-hydrostatic pressure has been developed based on a compact differencing method. By means of interpolation techniques in combination with a piecewise linear or a piecewise parabolic vertical pressure distribution, the effect of the non-hydrostatic pressure can be included using a very small number of layers (1-4). The small number of pressure layers reduces the computational time. The number of layers for the velocity may be taken equal to or larger than the number of pressure layers.

In its present state the model is able to simulate one-dimensional non-breaking waves. A first verification for waves with a low wave steepness showed fairly accurate results for a very limited number of layers (Figures 1 and 2).

Future work will include the extension to three dimensions, calculations for steep waves, irregular waves, and the implementation of a model for the simulation of wave breaking.

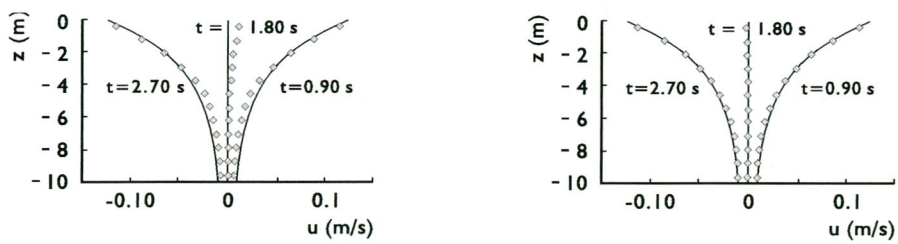


Figure 1.

Vertical distribution of the horizontal velocity of a standing wave in a closed basin in three instances. Solid line: analytical solution; diamonds: simulations using 12 velocity layers and 2 (left) or 4 (right) pressure layers.

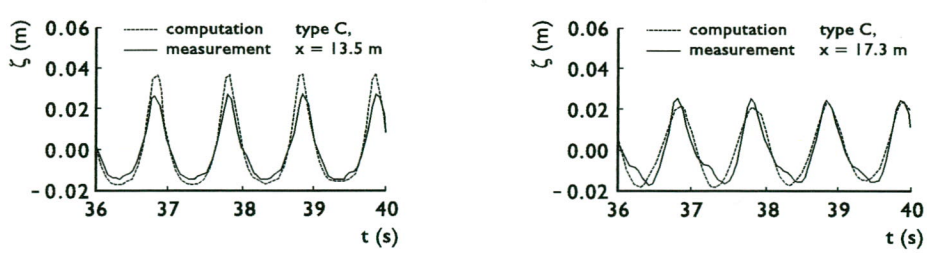


Figure 2.

Regular waves propagating over a bar. Water depth: 40 cm; depth at bar: 10 cm; wave period: 1.01s; wave amplitude: 2.05 cm. Left: surface elevation at x =13.5m (on top of bar); right: surface elevation at x =17.3m (directly after the bar). Computations with the non-hydrostatic model with 4 pressure layers are compared with measurements (Beji-Battjes experiment).

For further information please contact Jacco.Groeneweg@wldelft.nl or Mart.Borsboom@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Delft Cluster

Waves and currents in the vicinity of near-bed structures

Physical model tests have demonstrated that the situation in which both waves and currents interact with near-bed structures is complex and leads to behaviour which is still somewhat difficult to explain. Examples of situations in which knowledge of the resulting flow pattern is significant are studies concerning stability of pipeline covers and groins. The aim of the project was the modelling of this interaction using numerical means. Because the flow pattern is locally strongly 3D, locally a fully 3D viscous flow model must be employed. We have used the model CFX® for this purpose. In the remainder of the domain considered, a wave model is sufficient to achieve acceptable accuracy. The current is simulated by realising a coupling of CFX® and TRITON, a wave model developed at WL | Delft Hydraulics. The motivation behind this coupling is to employ the computationally expensive CFX® only where necessary, and to employ TRITON in the remainder of the considered domain. Because the CFX-domain is small compared with the total domain, the result has been the discovery of an efficient method of modelling.

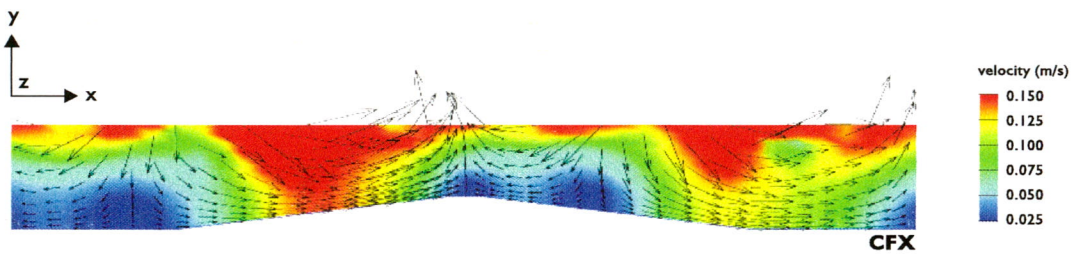


Figure 1.
Wave-induced velocity of a short non-linear wave in the vicinity of a near-bed structure.

Our expectation is that the computation of detailed flow patterns used as input for the analysis of the stability of near-bed structures will be possible given the developed approach, although it should still be validated based on physical model tests.

For further information please contact Ivo.Wenneker@wldelft.nl or Marcel.vanGent@wldelft.nl

Financed by (a.o.) Ministry of: Economic Affairs and private funding

BREAKWAT 3.0

BREAKWAT 3.0 is a tool used to support the designer in the preparation of a conceptual design of breakwater structures. The tool provides confidence bands for most design formulas, supporting the fact that reality may differ from the mean curve. It is advised to perform physical model investigations for detailed design of all important breakwater structures since structures in prototype may differ substantially from the conditions on which design formulas are based.

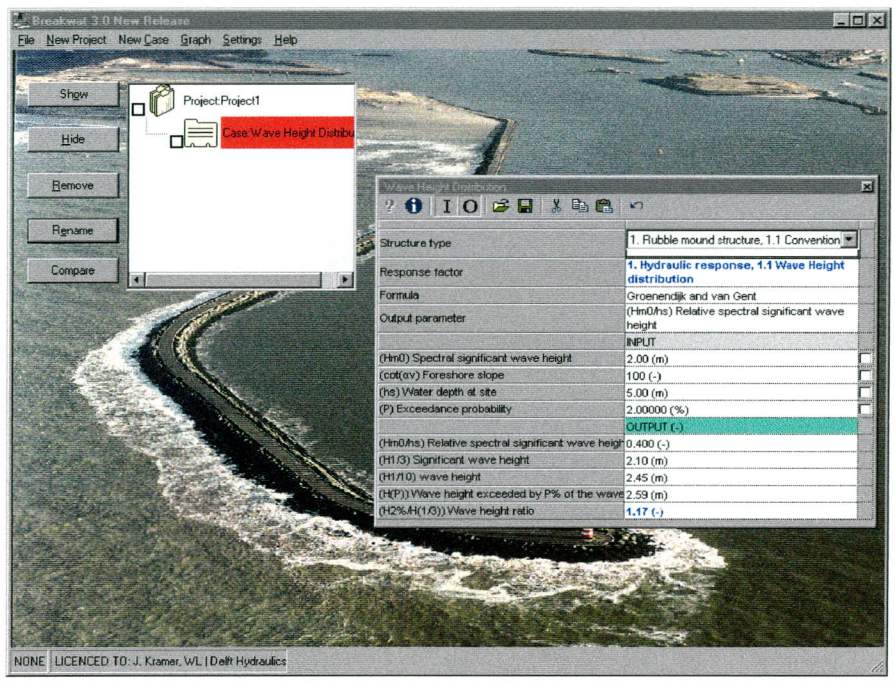


Figure 1.
Graphical User Interface, Breakwat 3.0.

The new release BREAKWAT 3.0 is an upgrade of version 2.02, dating from 1993, which has been widely used in the design of rubble-mound structures. It was based on studies of wave run-up, transmission and structural stability, mostly performed during the 1980's. In the past 10 years there have been new developments in the technical aspects of breakwater design as well as Input/Output and graphical presentation of results. The development of the new release BREAKWAT 3.0 incorporates many of these new improvements. Breakwat 3.0 includes most of the options currently available in version 2.02 as well as the following aspects:

- Windows (95/98/NT/XP)-based operation,
- Possibility to read from input files and to write results to output files,
- Possibility of calculating more than one scenario at a time (sensitivity analysis),
- Improved graphical presentation of results,
- New formulas for wave run-up, transmission and overtopping of sloped structures,
- Calculation of failure probability of rock armour layers,
- Stability comparison with Hudson formula for rubble-mound breakwaters,
- Calculation of longshore transport for berm breakwaters,
- Calculation of rear side stability of berm breakwaters,
- Calculation of stability of near-bed structures,
- Calculation of stability, transmission and overtopping of caisson breakwaters.

For further information please contact Jan.Kramer@wldelft.nl

4 Rivers and inland waters

Rivers and inland waters involve interconnected physical, chemical and biological processes, which together constitute a diversity of water environments in which people live and work. Sometimes these water systems are natural, but more often mankind tries to shape them to suit its needs. Since freshwater is a vital source of life for people all over the globe, WL | Delft Hydraulics is involved in many aspects of research and development related to inland water systems. The expertise at WL | Delft Hydraulics covers five major areas: flood management and hydrology, river engineering and morphology, water quality and ecology, regional and municipal water management, integrated river basin management. Because complex problems often require integrated solutions, available expertise also includes policy analysis as well as planning and decision-making practice.

In the year 2002, research and development in the field of inland water systems focused on various items, grouped into *research on processes* and *development of technology*:
in-depth studies were conducted to determine the possible effects of land-use changes in order to relieve flood situations, and the effectiveness of various measures to increase safety from flooding was investigated. Water management aspects were studied, such as the uncertainties in the prediction of habitats, the groundwater table effects during drought situations and the effects on water quality due to the exchange of substances adhering to sediments. A new set-up of the greenhouse concept was also examined.
Work continued on a planning tool for integrated river management and new concepts of flood-risk management and water-related spatial planning were investigated. Progress was made on methods used to quantify extreme hydrologic situations, urban water quality modelling, nutrient management and the effects of emissions.
The modelling of effects of vanes and screens in rivers as a means of influencing sediment transport and bed topography was improved further. The general river morphology modelling concept was reconsidered and a tool for the calculation of flood damage was designed. The possible use for participative decision-making in water resources planning was demonstrated.

Detailed knowledge in these areas is available at WL | Delft Hydraulics, and stems from long-standing practical experience and research on natural processes in inland water systems. Experimental research is used to obtain insight into physical, chemical and ecological aspects of water systems. Newly acquired knowledge is incorporated into modern software systems available for specialised consultancy. Whenever possible, field data are used for calibration and validation.

By coupling numerical simulation models to databases and geographical information systems, both internal and external users are provided with powerful tools. Participation in EU projects and other network organisations (Delft Cluster, the Netherlands Centre for River Studies) ensures that WL | Delft Hydraulics will maintain its prominent role in the development and application of water technology for in both the public and private water sectors.

Research on processes

- Extended floodplains, green rivers and detention areas; land use potentials
- Flood retention basins and nature development
- Uncertainties in habitat evaluation methods: method development and case study
- Effects of system behaviour on flood risks
- Using surface water as a means of controlling groundwater
- Actual realisation of objectives with respect to groundwater and surface water boundary conditions of aquatic nature types
- Sediment-water exchange of substances
- The integration of water quality in operational water management
- Floating greenhouses: a combining water storage and horticulture
- ENFRAIM: Environmental Flow Requirements; an Aid for Integrated Management

Development of technology

- Extreme value analysis for complex hydraulic and hydrologic systems
- Resilient flood risk management and spatial planning
- Nutrient management in the Danube Basin and its impacts on the Black Sea
- Emissions
- Incorporation of "extreme event analysis" in the Waternood-method
- Urban water-quality modelling
- The urban water cycle
- Vanes and screens in river management
- Damage module
- Innovation 2D river-modelling instruments (Delft2D-Rivers)
- Participative planning of water resources management

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Extended floodplains, green rivers and detention areas; land use potentials

The project relates to the societal discussion involving creating more room for the rivers for hydraulic functions such as discharge and/or storage of water. This places restrictions on land use, but may also trigger new developments and help to maintain and/or restore landscape quality in terms of natural heritage, cultural heritage and scenery.
First, an analysis of the changes in the room available for the Rhine and Meuse rivers during the period 1850-2000 was performed and published for the relevant audience in '*Het WATERschap*' (Klijn et al (2002)). This analysis proved that the room available for storage and/or discharge was reduced by more than half.
Secondly, a paper was written and submitted to the journal '*Landschap*' (and to be published in 2003) about the advantages and disadvantages of various strategies to increase the room for rivers from an ecological point of view. This paper was based on research conducted for the Ministry of Agriculture, Fisheries and Nature Conservation, entitled "Does room for rivers also imply room for nature?" The effects of various spatial configurations of dike relocations, detention reservoirs and green rivers (bypasses) on nature, biodiversity and habitat connectivity were assessed and reported. The manuscript is intended for a special issue:

'For the future of our river region ...!'
A symposium was organised under this same title in co-operation with the Netherlands Centre for River Studies (NCR) and the Dutch Society for Landscape Ecology (WLO). The symposium was held in Delft on 11 December 2002 and was attended by some 120 interested and enthusiastic participants, involved scientists as well as scientifically interested policymakers. The presentations will be published in the special issue mentioned above (in Dutch).

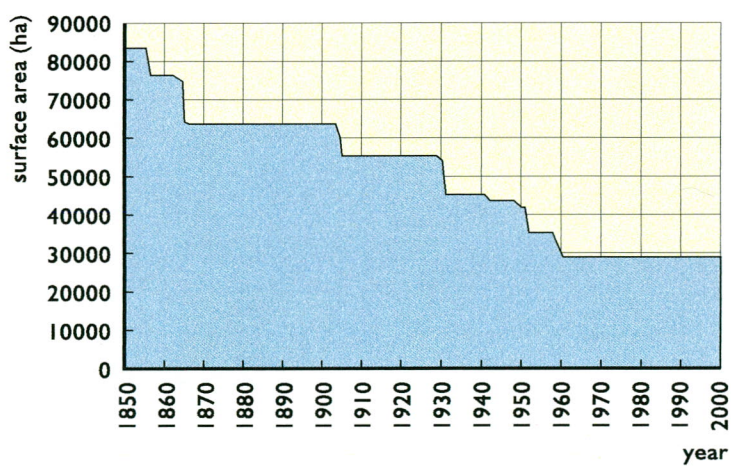


Figure 1.
Surface area available for storage and discharge along the Rhine branches from 1850 to 2000.

For further information please contact Frans.Klijn@wldelft.nl and Nathalie.Asselman@wldelft.nl

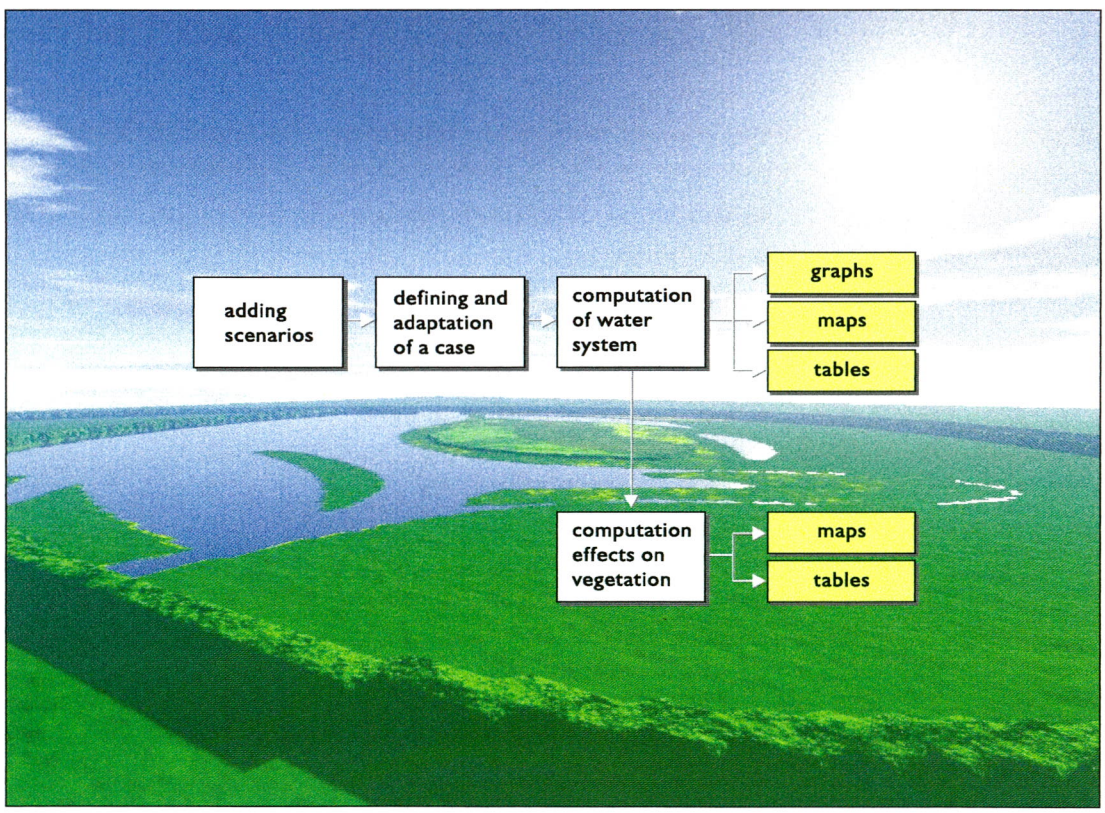
Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Flood retention basins and nature development

The increasing problems related to river floods forces us to consider the construction of retention basins. However, these basins may also be used for nature development and/or recreation in addition to their principal function, i.e. the storage of water during extreme floods. Obviously, the basin must be available as retention basin at all times, although the frequency of floods and subsequently, the frequency of inundation of a retention basin will be low. A retention basin requires hydraulic structures, such as intake and outlet structures, drainage channels, etc. If a retention basin must also serve as a nature project, a policy will be required with respect to the physical planning or land use of the area. This means that objectives should be available for the ecosystems as well as operating rules for the hydraulic structures used to regulate the water in the basin through ecological inundations in order to realise the desired vegetation.

The aim of the project was to build a decision support system showing the effects of an ecological inundation of a retention basin on the vegetation. Such a tool enables managing authorities to consider different options for using the water in order to maximise nature development by taking river discharge and the present and desired vegetation into account, while always keeping in mind that the basin must be kept available in the event of an extreme flood.

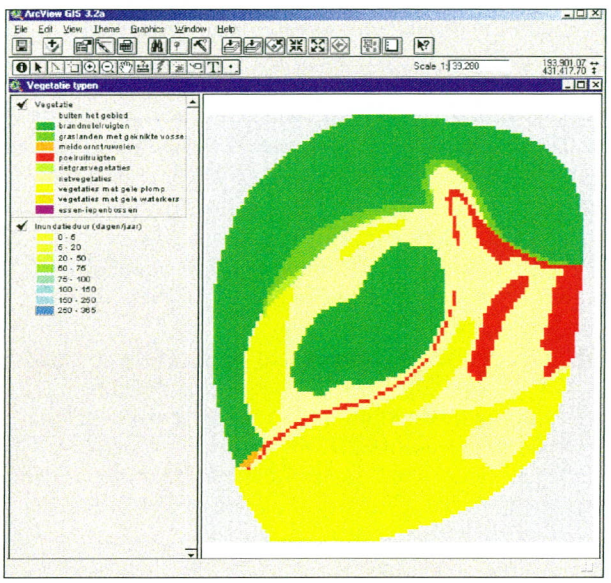
A prototype of a decision support system was built to serve as an example for decision makers, which provides recommendations on the possibilities of operating a flood retention basin which also performs an ecological function. A fictitious area was chosen which could fulfil the role of a retention basin and the desired ecosystems were divided over the basin in a natural way taking into account aspects such as elevation contours and inundation frequency. In addition, conceptual designs were created for the required hydraulic structures. Furthermore, information on the water-related ecosystems (required inundation frequency, inundation height, and duration of frequency) was collected, and a model for the vegetation succession was designed.



Starting screen of the DSS with an impression of the flow retention basin.

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Subsequently, a prototype of the decision support system has been built, which enables managing authorities to see the possibilities of creating and managing a flood retention basin with an additional nature development function. The management tool shows the effects of a particular management decision on the vegetation, for instance an ecological inundation. The prototype may easily be adjusted into a real decision support system for a particular area with a retention function by implementing the site-specific conditions and vegetation.



Example of the effects of a particular management decision on the vegetation.

For more information please contact Henk.Verheij@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Uncertainties in habitat evaluation methods: method development and case study

In the Netherlands, ecological rehabilitation of rivers and lakes is assigned a high priority in the planning and creation of policy for water and nature management. In order to assess the ecological impacts of rehabilitation measures, habitat models are often applied. For a general application of habitat models it is essential to ascertain their reliability. Therefore, sensitivity of the model outcomes for input data and model parameters should be specified, and the uncertainty in the model prediction should be explored. To estimate the reliability of habitat models applied in the Netherlands, sensitivity and uncertainty analyses were performed and a procedure was developed to estimate the uncertainty in habitat modelling due to uncertainty in the input data and index values of habitat functions. The results of the uncertainty analysis of habitat suitability index models demonstrate that the model results are primarily determined by two to four habitat factors. The interaction between uncertainty in input data and index values of habitat functions was affected by the properties of the slope of the habitat function at the value of the input map. The standard deviation was 0.1 to 0.2 at its maximum, which occurred at suitability indices of 0.4-0.6, and decreased at lower or higher indices. The maximum standard deviations in suitability indices were explained by a high estimated uncertainty in the function itself, as indicated by panels of experts, together with the steepness of the habitat function at indices of 0.4-0.6. Analysis of the contribution of individual habitat factors to the overall uncertainty indicated that water quality factors such as water clarity and phosphate concentration played an important role. The Figure below shows the uncertainty in habitat suitability due to uncertainty in indices of habitat functions (I), in input data (F), and in uncertainty of indices and input data together (I + F) at five representative locations in the Lake IJssel area.

In addition to an uncertainty analysis applied in the Lake IJssel case study, validation methods were also tested. In the case study suggestions were given to minimise uncertainties in input data. This project will continue in cooperation with projects with RIZA and RIKZ and will be subject of a Delft Cluster project initiative.

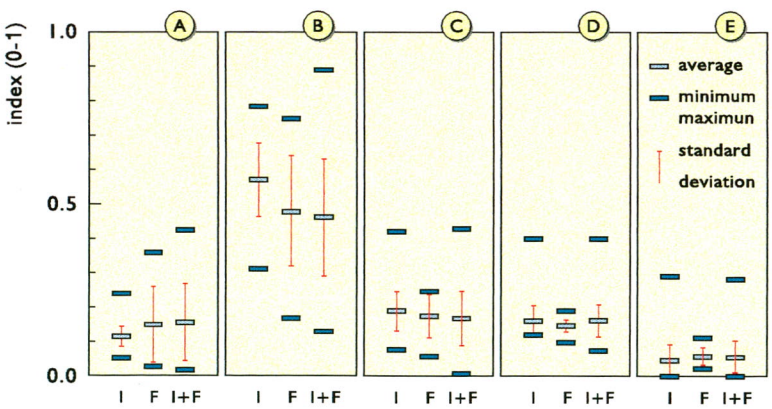


Figure 1.
Average, standard deviation, minimum and maximum of habitat quality at 5 selected locations A to E for 3 scenarios: uncertainty in model parameters alone, uncertainty in habitat factor alone, and uncertainty in both model parameters as habitat factors.

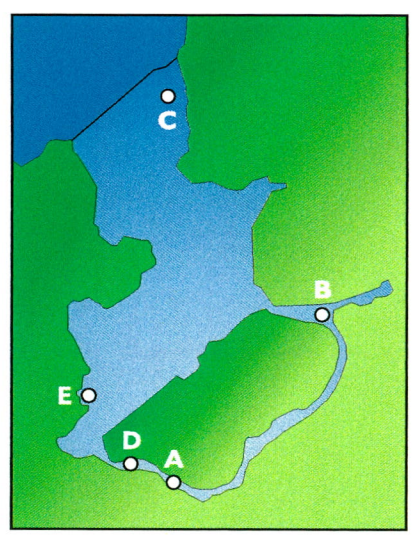


Figure 2.
Location of points A – E of the representative sites in the Lake IJssel area referred to in Figure 1.

For further information please contact Guda.vdLee@wldelft.nl, Harm.Duel@wldelft.nl and also D.T.vdMolen@riza.rws.minvenw.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Delft Cluster

Effects of system behaviour on flood risks

The effects of system behaviour on flood risks refers to the safety of a specific dike (ring)'s possible dependence upon the safety of other dike (ring) s. At present in the Netherlands, determining the safety of a specific dike (ring) does not involve the (partial) consideration of the effects of system behaviour. Effects of system behaviour may be either positive or negative. Furthermore, one may either accept the current system behaviour (passive attitude) or interfere (for instance by diverting flood water) with the current system behaviour (active attitude).

Within the framework of a Delft Cluster project (DC 02.01.01: Effects of system behaviour), a conceptual framework was developed, allowing for the determination of the effects of system behaviour in terms of flood risks (probability times flood damage). Within the conceptual framework which was based on Monte Carlo analysis techniques, aspects such as hydraulic, geotechnical and constructional factors as well as social elements were taken into account. In addition to WL | Delft Hydraulics (major participant), the following parties contributed to the previously mentioned DC project: Rijkswaterstaat DWW, TNO Bouw, GeoDelft and TU Delft.

Using the developed conceptual framework, two case studies were conducted. The results of these case studies were satisfactory with respect to the possibility of quantifying the effects of system behaviour on flood risks. A detailed analysis of the findings of the two case studies conducted is projected for early 2003. In addition, a concluding report will be prepared. It may be said with confidence that the developed conceptual framework is quite promising, however in future further elaboration on some of the aspects is recommended.

For further information please contact
Thieu.vanMierlo@wldelft.nl and
Karin.deBruijn@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Using surface water as a means of controlling groundwater

Introduction

Controlling the surface water levels in natural water systems is rarely a goal in and of itself. It is a means of ensuring sufficient moisture for crops and to prevent flooding. Since surface water is easy to control, it is often used to define the standards which should be satisfied by the local water management authorities. However, the availability of groundwater data has improved considerably over the last few years. This means that the previously mentioned standards might be shifted from surface water standards to groundwater standards. However, such a shift may only be made if hydrologists have sufficient opportunities for the calculation of phreatic groundwater regimes and their interaction with the surrounding environment.

The research project

The project investigates what occurs in the surrounding phreatic groundwater levels when the surface water system is modified. An example of this would be to make the channels both shallower and wider simultaneously. Shallower channels are supposed to promote the prevention of drought, and widening them would ensure that the groundwater levels will not rise excessively due to the fact that they have been made shallower.
An example is illustrated below. The graph shows two channel cross-sections: the red cross-section represents the original channel, and the blue cross-section is the same channel after modification. We calculated the effects of this measure on the surrounding groundwater levels.

Tools needed

During the course of the project, it became apparent that we lacked the tools necessary to arrive at a solution to the problem presented. Each available modelling tool has its own disadvantages: groundwater models use time steps (decades) which are too long resulting in wet periods often being neglected, and Rainfall-Runoff models were originally only designed to translate rainfall into an out flowing flux, and not to calculate groundwater levels.
A solution was found by applying the Rainfall-Runoff model in a *distributed* manner. Instead of applying only one modelling object (rainfall-runoff node) for each catchment area, these areas were now divided into several hundred modelling objects.

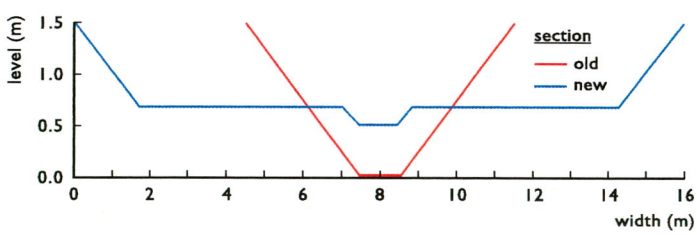


Figure 1.
The same channel before and after reshaping.

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

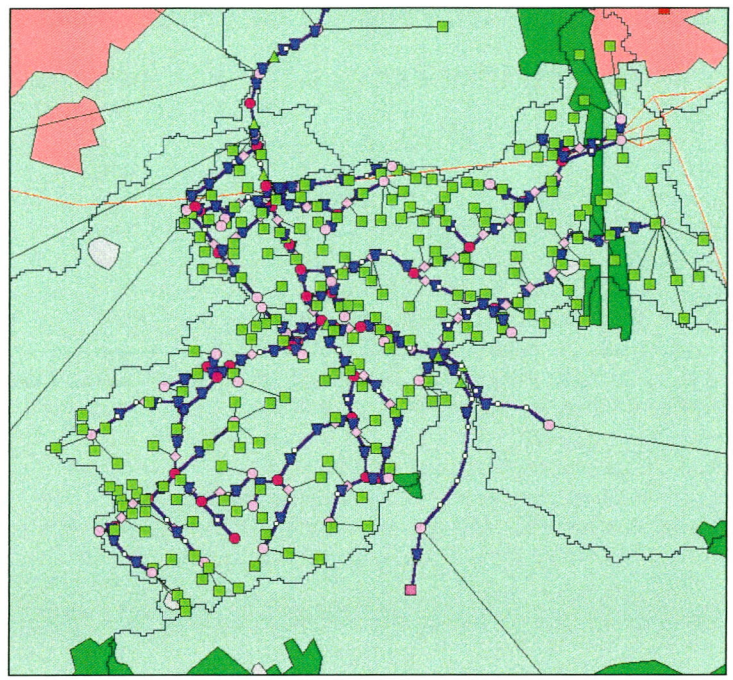


Figure 2.
Distributed modelling of a catchment area instead of the classic *lumped* method. The green dots represent rainfall-runoff nodes.

The results and conclusions

- Calculating detailed phreatic groundwater levels by applying a *lumped* rainfall-runoff model in a *distributed* manner is possible, yet very time-consuming and it lacks important processes such as flow of groundwater between nodes.
- After reducing the depth of natural channels, the low groundwater levels (dry periods) increase more than the high groundwater levels (wet periods). The effect is approximately a factor 2.
- Trying to compensate for the extra high groundwater levels that occur during wet periods (as a result of reducing channel depths) by widening the channels is useless. The effects of widening may only be observed up to a distance of 50 meters from the channel.
- There are presently no tools available that can combine detailed phreatic groundwater modelling, using a small calculation time step (minutes) and which may interact with a routing model and a groundwater model;
- The used Rainfall Runoff model SOBEK-RR should be redesigned to render it more suitable for detailed calculation of phreatic groundwater. First, phreatic groundwater flow between all modelling objects should be made possible. Secondly, distributed modelling with the model should be made more user-friendly (note: at the time this summary was written, the new concept was already in the process of being designed by the SOBEK development team.).

For further information please contact Siebe.Bosch@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Delft Cluster

Actual realisation of objectives with respect to groundwater and surface water boundary conditions of aquatic nature types

This project is part of a Delft Cluster project which is related to the STOWA research program "Waternood" and is entitled 'Weighing of land use type; Determination of optimal groundwater and surface water regime for nature types (OGOR)". In the 'Waternood' instrument, methods are being developed and implemented to estimate the actual realisation of objectives with respect to OGOR. A suitable method is lacking however for aquatic nature types. In this project a simple test method has been developed, which was specifically aimed for application in two case studies: the Reeuwijk Lakes and the Strijbeek stream and mires. For the determination of the OGOR, a set of relevant hydrological steering factors was selected per aquatic nature type, among which were several water quality factors. Response functions were defined for this set of factors.
Application of the test method appeared to be suitable as an analysis of bottlenecks in the realisation of OGOR. The estimates of the actual realisation of OGOR objectives were representative of the present status of the aquatic nature in the case studies. To enable application of the test method in scenarios with design measures in order to improve the OGOR, it is necessary to extend the method with model instruments suitable for the prediction of water quality in aquatic nature types after the implementation of measures.

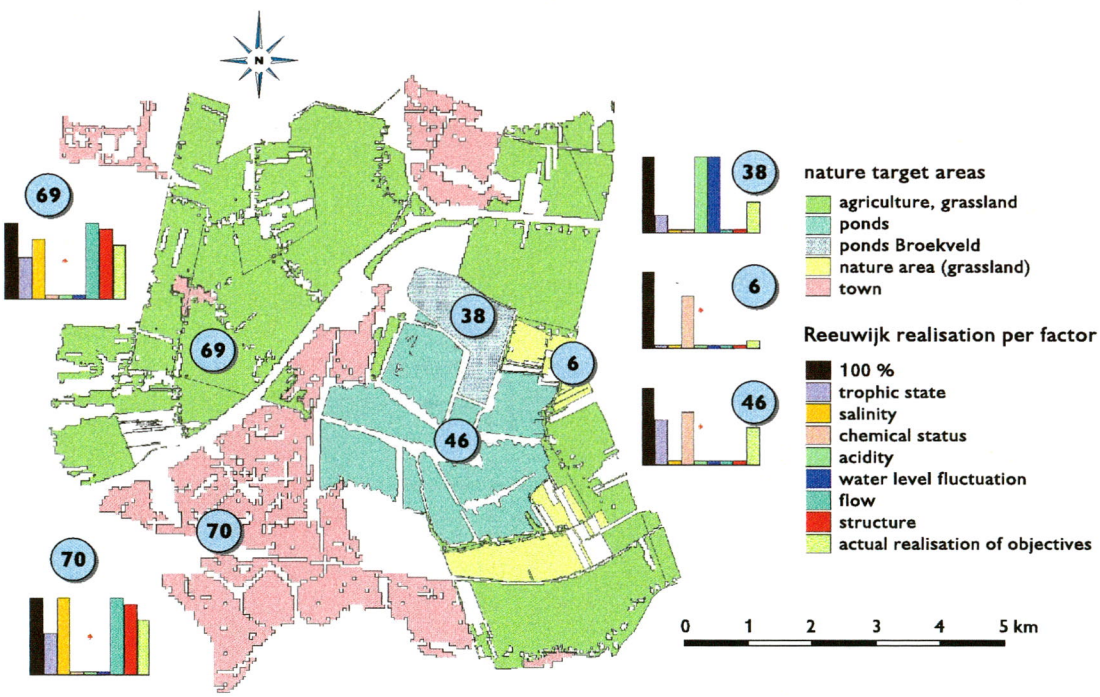


Figure 1.
Actual realisation of groundwater and surface water regime for aquatic nature types and actual realisation of individual hydrological factors in the Reeuwijk Lakes area. The values of these actual realisations were not satisfactory in most parts of the Reeuwijk Lakes area, mostly due to limitation by water quality, together with water level fluctuation.

For further information please contact Guda.vdLee@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

Sediment-water exchange of substances

The modelling of sediment-water exchange of substances has long been part of the water quality modelling activities at WL | Delft Hydraulics, especially with regard to nutrients. Over the years, various optional modules have been incorporated into the water-quality model DELWAQ for this purpose. The modules S1/2, SWITCH, SFM and GEMSED differ substantially with respect to complexity, numerical methods and flexibility. The innovation of sediment diagenesis modelling started in 2000 and was continued in 2002. The conceptual improvement and innovation, extension and validation of sediment diagenesis modelling are the goals of the project.

The activities in 2002 focused on the formulation and implementation of DELWAQ-G. In addition, literature study and the formulation of sub models for rooted macrophytes and the slow adsorption of organic micro pollutants onto organic matter have been carried out. DELWAQ-G is a new, generic version of the water- and sediment quality model DELWAQ. One set of generic water quality process formulations is used to calculate the rates of these processes in both water and sediment compartments. The local chemical conditions determine if and how processes are active.

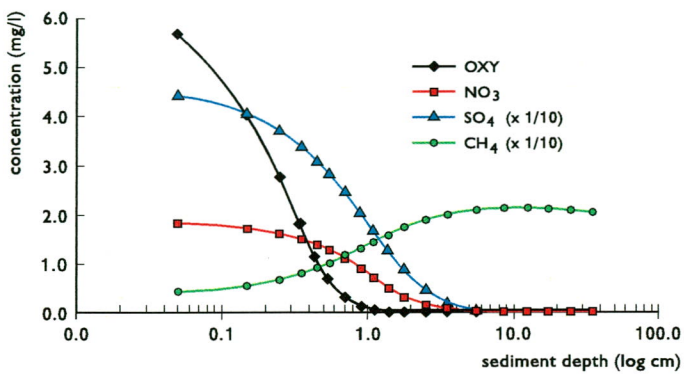


Figure 1.
The pore water concentrations ($g.m^{-3}$) of dissolved oxygen, nitrate, sulphate and methane simulated with DELWAQ-G in a steady state. Depth is displayed on a logarithmic scale.

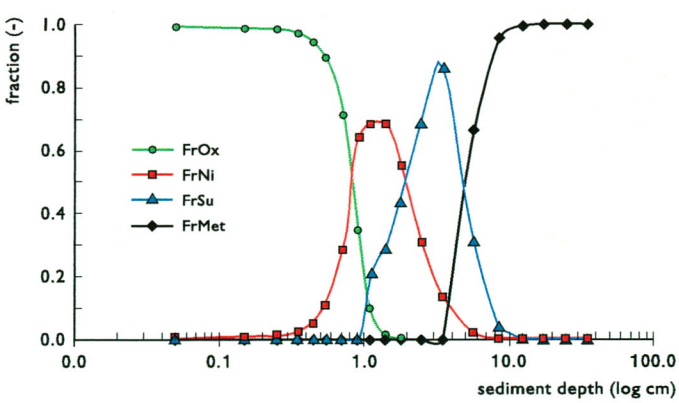


Figure 2.
The fractional contributions of oxygen consumption, denitrification, sulphate reduction and methanogenesis simulated with DELWAQ-G in a steady state. Depth is displayed on a logarithmic scale.

A number of the relevant processes such as the decomposition of organic matter had already been incorporated in DELWAQ in earlier stages of model development. The newly-implemented processes involve:

- consumption of electron-acceptors oxygen, nitrate, sulphate and methanogenesis;
- oxidation, precipitation and dissolution of sulphide;
- oxidation, ebullition and volatilisation of methane; and
- mass transport in the sediment by bioturbation, bio-irrigation, burial, digging and seepage.

The results of testing DELWAQ-G on a hypothetical case show that the model functions to satisfaction. The predicted concentration profiles in the sediment reflect the typical interactions of diagenesis processes.

The project is to be continued in 2003. In order to properly assess its performance, the application of DELWAQ-G to real marine and freshwater cases must be the next step in model development. DELWAQ-G will contribute substantially to more comprehensive and improved modelling of sediment-water interaction. The further operationalisation of DELWAQ-G will establish high flexibility in water and sediment quality simulation, since it will be easy to switch between complex and simplified applications.

For further information please contact Johannes.Smits@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Delft Cluster

The integration of water quality in operational water management

The primary goal of operational water management in polder-canal systems is to maintain the water level in the polders and the canals. However, a Delft Cluster feasibility study showed that it is also possible to improve the water quality in the polder-canal system with an operational water management method which takes the transport of pollutants into account. The Delft Cluster feasibility study discerned three levels of operational water management:

- The strategic level (the formulation of objectives);
- The tactical level (analysis of large-scale behaviour of the water system); and
- The operational level (implementation of the controllers for structures in the water system).

This research project focused on the third (operational) level. A theoretical situation was studied extensively, with the help of a model schematisation of a polder-canal system in SOBEK. The structures in a polder-canal system not only influence the transport of water, but also affect the transport of pollutants. By choosing a strategy in which water quality parameters are integrated, polluted water may be discharged out of the water system, and cleaner water can be conserved in the water system. In this way, the effluent of waste water treatment plants or the nutrient-rich discharge of a polder may be prevented from flowing towards a lake or a nature conservation area.

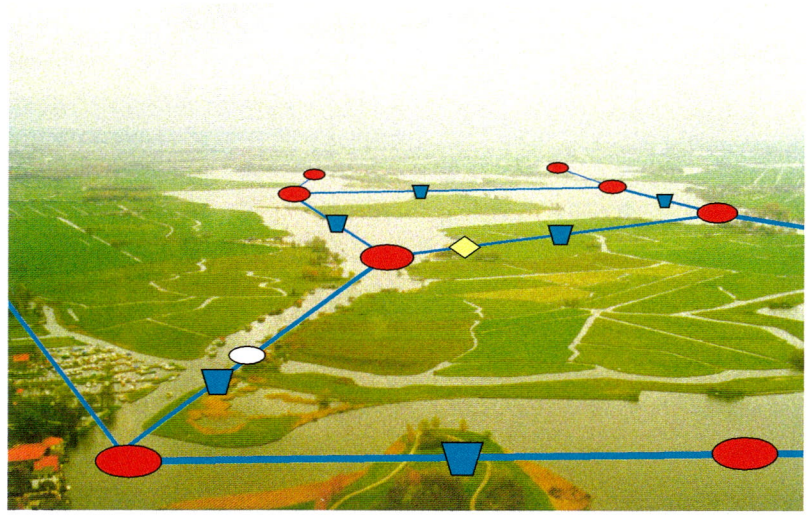


Figure Computational grid for Joppe/ / Kager Lakes.

The operational water quality management of the polder-canal system was studied in great detail for each possible situation: excess and shortage of water, water of good and poor quality in the polder and the canals, etc. The approach to the set-up and the testing of the controllers is described in a brief report.

For further information please contact Joost.Icke@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

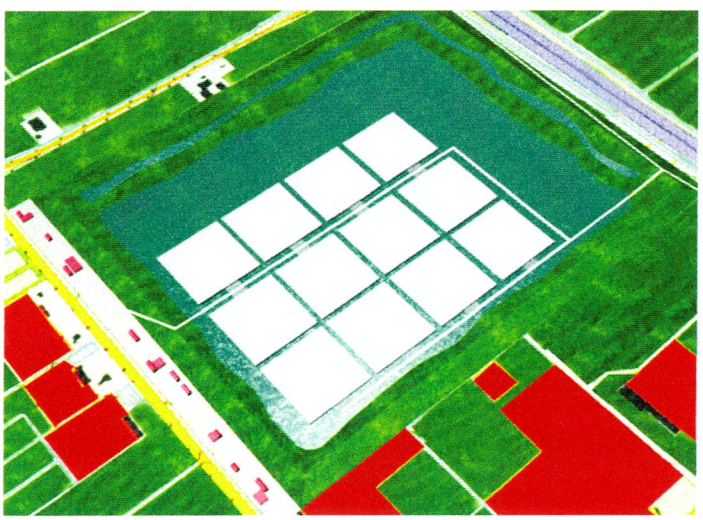
Delft Cluster

Floating greenhouses: combining water storage and horticulture

Water storage in polders can be used in a new solution to water management problems that are arising as a result of changing climactic conditions (intensified periods of drought and water surplus). However, this requires space. In the context of multifunctional land use, a feasibility study has been prepared in which the development of new areas for greenhouses was combined with water storage in the polder landscape: floating greenhouses in the case study area in the Haarlemmermeerpolder in the western part of the Netherlands. First a study of the water availability was conducted, after which water quality and ecological processes in the pond were assessed.

From a hydrological point of view, it is possible to realise the floating greenhouse concept in the case study area. However, many assumptions and boundary conditions had to be defined first in order to arrive at this conclusion. If the location changes, these assumptions and conditions must change as well, and a new feasibility study will have to be initiated. No absolute conclusions may be drawn with respect to water quality and ecology. The results from the water quality analyses are fairly positive for the open water section of the pond, but the covered section of the water storage pond is causing problems, especially with regard to the oxygen concentrations. As the greenhouses cover some 70% of the surface area involved in the case study, this should definitely be taken into account, as it also has negative effects on the ecological functioning of the pond. Nature may be sturdy and flexible, but the large water level fluctuations observed in the case study do not occur in normal situations at present, which makes comparison impossible. Also, the uncertainties regarding the water quality situation mean that at best, only a rough estimation of what will happen may be provided.

During the project, suggestions have been made to implement technical solutions for the oxygen problems. A re-aeration system consisting of tubes installed underneath the floating greenhouses has been used elsewhere and was found to be effective in decreasing the oxygen deficit. These types of technical solutions can be very effective when the goal is to implement the floating greenhouses concept in a successful and sustainable way. In general, the effects which occur will need to be monitored in a real project to fill the gaps in knowledge which are present. At the time this was written (December 2002), plans were in the works to initiate a pilot study in which a floating greenhouse will be built as a test case.



Design of the water storage pond with 70% coverage of floating greenhouses.

For further information please contact Lennart.Silvis@wldelft.nl or Ellis.Penning@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management / Education, Culture and Science

Delft Cluster

ENFRAIM: Environmental Flow Requirements; an Aid for Integrated Management

As a tool for managers, *Environmental Flow Requirements* (EFR) have attracted attention due to their lack of ambiguity in operational management. However, the *assessment* of EFR is much more complex, especially if both riverine and coastal downstream requirements are to be included in the process. Therefore, the need to develop a clear method for assessing EFR and turning it into an adequate (i.e. effective and efficient) planning tool for integrated river and coastal management remains high.

The main objective of this three-year Delft Cluster project is *to develop the concept of Environmental Flow Requirements into an adequate (i.e. effective and efficient) planning tool for integrated river and coastal management.* The project is being conducted jointly by WL | Delft Hydraulics, TU Delft and IHE with participating sector partners Alterra and BUET (Bangladesh).

Transport on the Teesta River, Bangladesh.

In 2001 the ENFRAIM project began with a review of existing EFR methodologies. The main conclusion arising from this review is that there is a vast amount of methods being developed throughout the world geared towards setting Environmental Flow Requirements, either for specific rivers or specific regions. Particularly in North America, many Environmental Flow Assessments are developed with respect to the conservation of fish habitats, whereas in South Africa, for example, a holistic approach is most frequently used. However, it often occurs that not all of a river's functions are taken into account (functions which include flood mitigation, recession agriculture, drinking water, local fisheries, delta formation and stabilisation).

In 2002 attention was focused on the way in which one should deal with these functions when setting environmental flow requirements. Specific local issues regarding climate, geomorphology, functions sustained by the river and requirements of different parts of the complete river basin ecosystem in different parts of the world should be taken into account when determining an EFR. Case studies in Bangladesh, Hue Basin (Vietnam) and the Incomati River have been initiated, and it appears that the best way to arrive at a properly defined EFR is to start by making a proper assessment of the objectives of the definition of an EFR (for what functions and under which circumstances).

In 2003 attention will be placed on how to combine the gathered knowledge into a generally applicable framework which may serve as a guideline for river basin managers in such a way that it will be of use within the proposed case studies.

For further information please contact Marcel.Marchand@wldelft.nl

Financed by (a.o.) Ministry of: Transport, Public Works and Water Management

NCR

Extreme value analysis for complex hydraulic and hydrologic systems

In this research project various methods for deriving extreme value statistics were analysed and/or developed. The investigated methods vary from straightforward direct extrapolation of measurements to more complex methods in which statistics are based on results of large numbers of simulations with physically-based models.

Important aspects of the research were:

- Identification of the input parameters which should be considered as a stochastic variable in the analysis.
- Derivation of probability distribution functions for the stochastic variables.
- Recognition and quantification of statistical dependencies between stochastic variables.
- Identification of the method most suitable for solving specific problems.

A number of case studies were performed. The first case study was the extreme value analysis of the water level of the IJssel Lake, in the Netherlands. Extreme value statistics were derived using both direct extrapolation and numerical integration methods. Both methods show more or less similar results for relatively low recurrence intervals (<20 years). However, for larger recurrence intervals, the results of the two methods clearly diverge. Furthermore, the influence of (statistical) dependency of the involved natural variables on the final outcome has been quantified. Further analyses are required to fully explain these differences.

In addition, a start has been made to perform a case study for water levels in a small polder system in the Netherlands. This particular case study will be the main focus in 2003. The main reason to select more than one natural system is to determine if some methods are consistently better than others, or otherwise if the suitability of a method depends strongly on the investigated problem.

This project is performed in co-operation with the Institute for Inland Water Management and Waste Water Treatment, Ministry of Transport, Public Works and Water (www.riza.nl)

For further information please contact Ferdinand.Diermanse@wldelft.nl