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IAHR AIRH
International Association for Hydro-Environment Engineering and Research

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EDITORIAL

IAHR 80 YEARS YOUNG AND BACK IN THE HAGUE AFTER 60

BY ARTHUR MYNETT

When IAHR was established in 1935, Johannes Theodor Thijsse, Professor at Delft University of Technology and Director of Delft Hydraulics, was elected to the position of Secretary General. For 66 years until 2001 he and his successors hosted the IAHR Secretariat in Delft. Emeritus Professor and former Secretary General Henk Jan Overbeek reflects on the origin and early days of IAHR in this Special 80th Anniversary Issue of Hydrolink. Shortly after the major coastal flooding in 1953, when the Dutch government was developing the Delta Plan to safeguard the Netherlands against future floods, the 6th IAHR Congress was held in 1955 in The Hague. Since that time, the membership has grown from some 400 to almost 4000 at present, and IAHR has expanded its offices to include Madrid and Beijing.

***Arthur Mynett* is Professor of Hydraulic Engineering and River Basin Development at UNESCO-IHE Institute for Water Education in Delft, the Netherlands. He is Chair of the Water Science & Engineering Department and involved in education, research and capacity development around the world. His research interests are in river engineering, flood risk management, water-related hazards, environmental hydroinformatics and eco-hydraulics. He is promoting applications of new concepts developed in the Netherlands (e.g. Building with Nature, Flood Resilience, Room for the River, Delta Technologies) to river basins in Africa, Asia, and Latin America. He is Chair of the LOC of the 36th IAHR World Congress.**

Although the Delta Works are completed for some time already, the Netherlands is still heavily involved in building 'Deltas of the Future'. Ambitious investment programmes in research and development and continuous equipment innovation play an important role in keeping ahead as a country known for its hydraulic engineering skills. The concept of Building with Nature heavily relies on multi-disciplinary collaboration in the context of the so-called Dutch Diamond, as elaborated in a joint article from two major dredging companies.

Along the same lines, the Dutch 'Topsector Water' focuses on international cooperation. The Netherlands is actively involved in exploring sustainable solutions on flooding, disaster risk reduction and freshwater supply in close cooperation with international partners. The joint approach on developing a new master plan for the protection and development of the city of Jakarta in Indonesia is a good example referred to in this Special Issue.

The Dutch Water Authorities, which originate back in the 13th century, are an ever-renewing heritage and example of adaptive water governance and operational management, typical for the country of the Netherlands, where more than half of the population and economic activity is below sea level. How to secure its very existence may become clearer after reading this Special Issue.

A typical example of present day hydro-environment engineering practice is presented in the article on the Canal del Dique system, located in the North of Colombia. Large scale rectification and enlargements of the cross section in the mid 80's have resulted in a gradual enlargement of the flow capacity of the canal, leading to major environmental and social problems. With the help of hydraulic and bathymetric data analysis, aerial photographs and a 1D/2D hydrodynamic model, it was possible to derive measures to start the environmental restoration of the eco-system the Canal del Dique System.

The need for large scale model testing is still relevant to assure dike and dune stability, without which the Netherlands could not secure its safety and economic prosperity. The newly constructed Delta Flume at Deltares in Delft with its advanced control features and measurement techniques, is a recent example of advanced capabilities for research on breakwater stability, bed protection, offshore wind farms, and storm surge barrier construction.

Big data have also entered the field of hydro-environment engineering and research, as illustrated in the article on 'pervasive sensing and ubiquitous computing: opportunities, challenges'. Some early successes are presented in the field of oceanographic and coastal modelling in the waters around Singapore, where recently Singapore's National Environmental Agency (NEA) initiated a real-time water quality monitoring programme to support the Singapore Government agencies in the management of the coastal waters – the so-called Project Neptune. Such water quality issues are indeed at the heart of IAHR. So is the need for advancing the field of fluid mechanics to deal with environmental issues as clearly illustrated in the article on oil spill modelling and the practical implications in the case of a blow-out, as occurred in the Caribbean Gulf some years ago.

Quality Assurance (QA) is another area of significant interest, as illustrated for the case of the Room-for-the-River programme. In the 1990s the Netherlands changed its policy on river flood management, away from recurrently raising embankments and moving towards making more 'room for the rivers'. In 2006 it was decided to implement 39 measures to deal with design flood levels, at the same time enhancing spatial quality. In order to ensure that this goal was met a Quality Team was established, as explained in the accompanying article.

The 36th IAHR World Congress in The Hague triggered the genesis of the IAHR Young Professionals Network Delft, as elaborated in this issue. The activities developed for the 36th IAHR World Congress in The Hague include (i) speed networking, where YPs meet the leaders of companies in the water sector, (ii) soft-skills workshops, (iii) YPN Forum, (iv) technical tours and (v) evening programs.

Please enjoy this Special Hydrolink Issue and the 36th IAHR World Congress!

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Cover picture: Windmills of Kinderdijk, The Netherlands (UNESCO World Heritage). *Photo: Thinkstock*

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IN THIS ISSUE

BUILDING THE DELTAS OF THE FUTURE

BY HENDRIK POSTMA, MARK VAN KONINGSVELD & STEFAN AARNINKHOF

Hoppers of Van Oord (left) and Boskalis (right) working together in the construction of the Rotterdam Port Extension Maasvlakte II.

The Netherlands is home to two of the largest dredging contractors in the world. Both companies have seen a gradual growth over the last 100 years, alongside with a series of iconic hydraulic engineering projects in The Netherlands as well as abroad. Ambitious investment programmes in research and development and continuous equipment innovation have played an important role in keeping the Netherlands ahead as a country known for its hydraulic engineering skill. Recent R&D efforts focused on the development of improved methods for the design and implementation of marine infrastructure, based on the concept of Building with Nature. The latter heavily relies on multi-disciplinary collaboration in the context of the so-called Dutch Diamond, consisting of the private sector, government, NGOs and knowledge institutes. It is our ambition to maintain this leading role and become a key player in Building the Deltas of the Future.

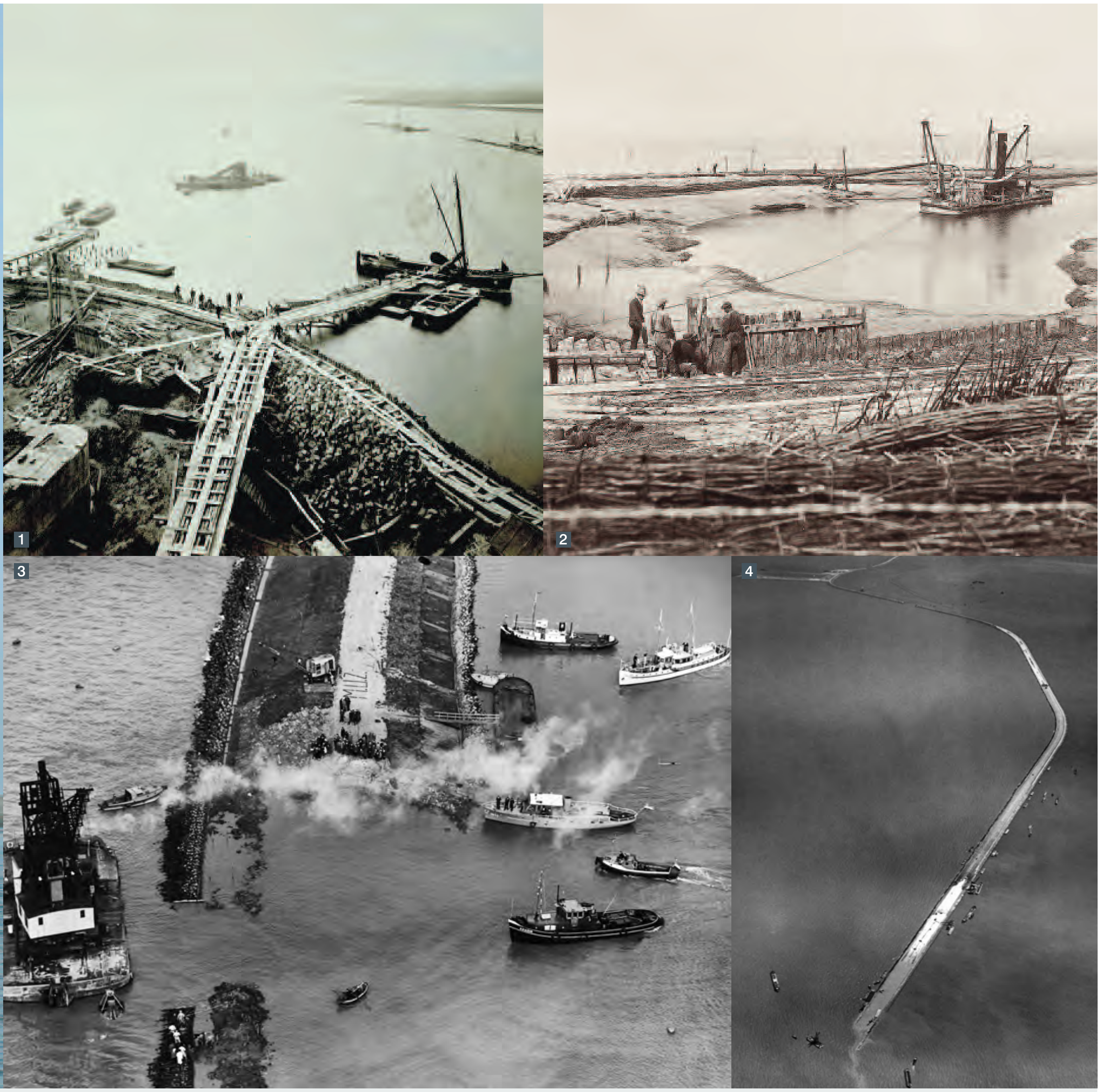


Figure 1 - Impression of the nature of dredging works in the late 19th and early 20th century. 1: construction works on the Noordzeekanaal (1865-1876). 2: construction works on the Eemskanaal near the port of Delfzijl (1866-1876). 3 & 4: construction works on the Afsluitdijk (1927-1932).

The Dutch dredging industry: historic perspective

The history of the Dutch dredging industry is shaped by a culture of innovation and entrepreneurship. The industry finds his roots in the second half of the 19th century, in the villages and cities built in the swampy wetlands surrounding the Biesbosch region just southeast of Rotterdam. Most companies started out as family-owned businesses aiming to make a living with small-scale maintenance dredging and construction of river bank and shore protection schemes. The works were carried out with highly artisanal techniques, and were paused during the cold winter months.

Driven by challenging projects in the Netherlands as well as abroad, the Dutch dredging industry has seen a major scale increase over the last hundred years. This involved both the dimensions and production rates of the dredging equipment, as well as the size of the companies themselves. Persistent consolidation of various smaller companies into larger organizations has nowadays resulted in a small number of major players, of which Boskalis and Van Oord belong to the five largest international dredging contractors worldwide.

These developments can be put in historic perspective along the lines of three major hydraulic engineering project in The Netherlands:

Figure 2 - Overview of large projects that over the years have shaped the development in dredging equipment and vice versa.
1: construction of the Rotterdam port extension Maasvlakte II (Netherlands). 2: construction of the Sand Motor Delfland (Netherlands). 3: sandy strengthening of the Hondsbossche and Pettemer Sea Defence (Netherlands).
4: construction of Palm Jumeirah (Dubai). 5: construction of the West of Duddon Sands Windpark (UK). 6: construction of the Eneco Luchterduinen Windpark (Netherlands).

1. Construction of the Nieuwe Waterweg (1866-1872), a new, man-made entrance to the North Sea that enabled Rotterdam to become a port of international standing. Historic pictures (Fig. 1) reveal the labour-intensive nature of the work, owing to the massive scale of the project and the artisanal work methods in use at the time.
2. Devastating floodings in 1916 lead to the construction of the Afsluitdijk (1920-1932), which dramatically shortened the coastline and turned part of the former Zuiderzee basin into a fresh water lake we now know as IJsselmeer. The project marks the transition from artisanal techniques to science based engineering; it inspired the establishment of world-renowned research institutes Delft Hydraulics and GeoDelft. Both institutes merged into Deltares in 2008.
3. Following the 1953 flood disaster in the Southwest Delta, the Dutch government initiated the Deltaplan that foresaw in the construction of a series of hydraulic engineering infrastructure projects to ensure safety against flooding, improve accessibility of the Delta region and create fresh water reservoirs for agriculture. The Delta Works commenced in 1958 and were completed in 1997. Rather than designing infrastructure to deal with floods witnessed in the past, the Delta Committee proposed to establish safety norms based on an economic analysis optimizing the cost associated with provided safety levels and the economic value in the hinterland. The safety levels reflect the probability of occurrence of the design conditions that the infrastructure should just be able to withstand. The optimal levels are embedded in law. Starting out with 'traditional' tidal closures, growing environmental awareness urged the design engineers to revise the later barriers into open structures, to maintain existing ecological values. As such, the Eastern Scheldt storm surge barrier marks a paradigm shift to multi objective design.

The strong home market enabled the Dutch hydraulic engineering sector to build up a competitive edge in the field of dredging and construction of marine infrastructure projects, thus providing a sound base for international expansion. This started towards the end of the 19th century and in the first decades of the 20th century with the construction of various port and shipping channels in Argentina, Indonesia and the United Kingdom. As of the 1970's Dutch companies became increasingly active in the Middle East in the construction of land reclamations and several ports, such as the Port of Jubail in Saudi Arabia. From the 1990's onward, construction of several very large infrastructure projects, such as the Oresund fixed link project between Sweden and Denmark, the Chek Lap Kok project, in Hong Kong, and the Singapore land reclamations at Pasir Panjang illustrated the trend towards the development of ever larger dredging vessels. These contributed importantly to the construction of Dubai's Palm Islands in the first years of the 21st century. The past decade was coloured by several mega projects in Australia related to mining (iron ore and coal) and LNG processing and export, carried out under the most strict environmental regulations

Recent years have shown a further expansion of the scope of works towards the offshore, including the development of deep sea mining activities and prominent involvement in the installation of Offshore Wind Farms. This culminated into the construction of some of the largest windparks presently in development, including the Eneco Luchterduinen Windpark, the Gemini Windpark (both in the North Sea) and West of Duddon Sands in the Irish Sea. These developments illustrate the permanent need for innovation, while entering new fields and exploring new horizons in the field of hydraulic engineering (see Fig. 2).

Science and innovation in dredging technology

The projects in the previous section illustrate the importance of innovation and increasing scale, both in dredging efficiency and company size. The challenges presented by the increasing scale of infrastructure projects over time, triggered dredging companies to invest primarily in technological development. This mainly resulted in the construction of ever larger, stronger and more efficient dredging and excavation equipment.

Of key importance, for example, was the development of the so-called Jumbo Trailing Suction Hopper Dredge (TSHD), that were able to hold over 40.000 m^3 of sediment in their hopper and reach productions that were roughly two orders of magnitude larger than that of smaller scale models (from approximately 200 m^3/hr of the early models to well over 10.000 m^3/hr for the most modern equipment). This scale step in TSHD equipment enabled a dredging production of well over 1 million m^3/week in projects like the The World in Dubai as well as the construction of the extension of the Port of Rotterdam: Maasvlakte II and the Hondsbossche and Pettemer seadefence. A similar scale increase can be seen in the development of backhoe dredgers, with the backacter, that can haul as much as 25 m^3 of sediment in one haul, as the current pinnacle. Likewise the Cutter Suction Dredger (CSD) was developed over the years, resulting in a one order of magnitude increase measured by cutter power (from approximately 200 kW to well over 7000 kW). Another major innovation was the introduction of the so-called self-propelled CSD. This made these very large vessels much more flexible in terms of deployment and manoeuvrability. Furthermore the increased size of the vessels dramatically increased their workability characteristics.

> **The Jumbo Trailing Suction Hopper Dredge (TSHD) are able to hold over 40.000 m^3 of sediment in their hopper**

The ongoing increase in the capabilities of dredging equipment, initially triggered by challenges presented by large infrastructure development and competition, in turn inspired project developers to think of new projects of a scale that was previously unimaginable. The design and construction of the Palm Islands in Dubai, and more recently the construction of the Suez Canal expansion in a record time, are examples that clearly illustrate the scale at which dredging industry is able to meet project developers' requirements.

Ongoing investments in dredging equipment has turned the dredging business into an asset driven and highly capital intensive industry. As a result, dredging research and technology development has long been focussed on production optimisation. The Dutch dredging sector was early to realise that it would pay off to fund and perform fundamental research on dredging technology together, in order to stay competitive on the world dredging market. The collaboration was effective since the research focussed on pre-competitive knowledge development. Each company retained its own responsibility to translate the research findings into daily practice. For the various Research & Development projects, the dredging companies set up a strategic alliance (SSB), which has been in operation for more than 20 years now and tapped into the knowledge and expertise of available research institutes in the Netherlands such as Deltares and the various technical universities. Topics studied by this research alliance include:

- the operational performance of various types of dredger in different weather and sea conditions;
- computer models for hydraulic transport;
- quality control for process water;
- and design methods for weak soils.

More recently technological developments focus more on societal issues such as the reduction of fuel consumption and CO_2 emissions: cleaner engines, efficient ship hull design, more efficient ways of equipment operation, etc.

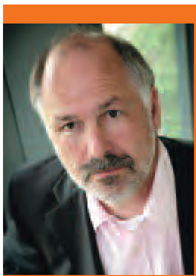
As part of that collaboration the Dutch dredging sector is involved in various doctoral research and graduation projects and even sponsors the chair Dredging Engineering at Delft University of Technology.

Science and innovation in project design: Building with Nature

Around the start of the 21st century Dutch dredging companies where among the first to realize that the ever increasing scale of dredging projects and the increased public awareness of sustainability, in combination with external triggers like climate change and accelerated sea level rise, called for a paradigm shift in the development and design of hydraulic engineering infrastructure.

In an effort to develop a new method for project development and operation, Dutch dredging companies Van Oord and Boskalis took the initiative for the Building with Nature (BwN) innovation programme. Starting from the natural system and making use of nature's ecosystem services, BwN attempts to meet society's needs for infrastructural functionality, and to create room for nature development at the same time. By including natural components in infrastructure designs, flexibility, adaptability to changing environmental conditions and extra functionalities and ecosystem services can be achieved, often at lower costs on a life-cycle

Figure 4 - Presentation of the Building with Nature book at the final congress of the first phase of the innovation programme in 2012 (from left to right: Harry Baayen (managing director of Deltares), Jan Schaart (director of Van Oord Nederland and member of the EcoShape supervisory board), Huib de Vriend (scientific director of Deltares and managing director of EcoShape) and Renske Peters (director of Water at the Ministry of Infrastructure and Environment)



***Hendrik Postma* graduated as a coastal engineer from Delft University of Technology and has more 30 years of experience in the field of dredging. He held several management positions on Boskalis projects worldwide. At this moment Hendrik is director at Boskalis Netherlands. Besides his role at Boskalis, Hendrik is chairman of the Supervisory Board of the Foundation EcoShape | Building with Nature, chairman of the Vereniging van Waterbouwers and chairman of the Kernteam Delta Technology, which forms part of the Top Sector Water.**

***Mark van Koningsveld* studied at the University of Twente in Enschede, the Netherlands, where he received an MSc (1998) and subsequently a PhD degree (2003) in Civil Engineering. After several years of working for Deltares he joined Van Oord (2008) where he currently is Manager R&D Engineering and Lead Engineer Environmental Engineering. Besides his role at Van Oord Mark actively participated in the Building with Nature programme, among others as program manager and Management Team member of the Foundation EcoShape | Building with Nature. Finally Mark is Secretary of the Top Team of the Top Sector Water, representing the business node of the Dutch Diamond (government, research institutes, businesses, NGO's).**

***Stefan Aarninkhof* is deputy manager of Hydronamic, the in-house engineering department of Boskalis. He graduated as a civil engineer from Delft University of Technology in 1996. He subsequently received a PhD, also from Delft University, and worked for 10 years at Delft Hydraulics (nowadays Deltares) before joining Boskalis in 2006. Stefan worked on a variety of projects worldwide, including the Khalifa Port and Coastal Zone project (UAE) and the Zandmotor (NL). Until recently, Stefan held the position of program manager and Management Team member of the Foundation EcoShape | Building with Nature. In his present capacity, Stefan is, amongst others, responsible for the environmental engineering group.**

Figure 5 - Restoration of mangrove shorelines in Demak (Java, Indonesia). In March 2015, the Indonesian and Dutch government launched a comprehensive five-year multi million public-private partnership initiative for enhancing coastal safety at the North Coast of Java. It aims to build stable, natural coastlines with reduced erosion risk through a unique integration of mangrove restoration, small scale hard-engineering and sustainable land use. The large-scale pilot project in Demak district focuses on safety against flooding along a 20 km stretch of coastline and sustainable revitalization of 6000 ha of aquaculture ponds. The approach includes a combination of technical and socio-economic measures, as well as creating an enabling environment through stakeholder dialogues and capacity building. The ultimate goal is to enable replication and up-scaling of the concept, for incorporation in a variety of urban and rural development programs.

basis than 'traditional' engineering solutions. To achieve public support, project development was to be seen as a process of co-creation where people from different disciplines work together to come to appropriate project designs.

The BwN programme, which is run by the EcoShape foundation, has now entered its second phase. The first phase ran from 2008 – 2012. The program received funding from the Dutch government, the EU, municipality of Dordrecht and private industries (all cash), as well as in-kind contributions from consultancies, research institutes and universities. The total programme budget for Phase 1 amounted to approximately € 32 million. Key outcomes of Phase 1 include, amongst others, various full scale pilot applications with associated monitoring programmes, a wiki based guideline to support the development and design of Building with Nature solutions, a glossy booklet (Fig. 4) outlining the basic philosophy of Building with Nature, 19 PhD theses and a wide range of scientific articles and technical reports.

The second phase of the EcoShape Building with Nature program runs from 2013 – 2018. The current programme budget is approximately € 38 million and funded from similar sources. A major difference, though, is that this funding was to be secured on a project by project basis. This yields a much wider range of funding sources, which make the programme's governance more complicated, but also increases the basis of support for Building with Nature.

Key to both the first and the second phase of the BwN programme is the realisation that all partners of the so-called Dutch Diamond, viz. the private sector, government, NGOs and knowledge institutes, should be involved in the development of the new design method to ensure that is achieves its maximum potential. A key example of a project that follows this approach is the mangrove restoration pilot in Demak, Java, Indonesia (Fig. 5).

In summary

Over the years, challenging hydraulic engineering projects worldwide have inspired Dutch contractors Boskalis and Van Oord to develop a competitive edge in the field of dredging and marine infrastructure construction. This position was maintained through continuous innovation and development. Initially, R&D efforts focused on the improvement of dredging technology, which lead to a scale increase in dredging equipment – and subsequently the infrastructure projects involved. More recently, the R&D scope was expanded to include the development of sustainable methods for the design and implementation of marine infrastructure, based on the concept of Building with Nature. It is our ambition to maintain this leading role and become a key player in Building the Deltas of the Future

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DUTCH WATER AUTHORITIES- WATER GOVERNANCE AS AN EVER RENEWING HERITAGE

BY PETER GLAS

You might say the Dutch have water running through their veins. Water management is part of our history and national pride but first of all a necessity to survive as a country. In the Netherlands the regional water authorities maintain the conditions for the Dutch people to live in the safest and cleanest delta in the world.

The Roman naturalist Pliny writing in the first century, described the inhabitants of the Low Countries at the edge of the world:
"There, twice in every twenty-four hours, the ocean's vast tide sweeps in a flood over a large stretch of land and hides Nature's everlasting controversy about whether this region belongs to the land or to the sea. There these wretched peoples occupy high ground, or manmade platforms constructed above the level of the highest tide they experience; they live in huts built on the site so chosen and are like sailors in ships when the waters cover the surrounding land, but when the tide has receded they are like shipwrecked victims. Around their huts they catch fish as they try to escape with the ebbing tide. It does not fall to their lot to keep herds and live on milk, like neighboring tribes, nor even to fight with wild animals, since all undergrowth has been pushed far back."

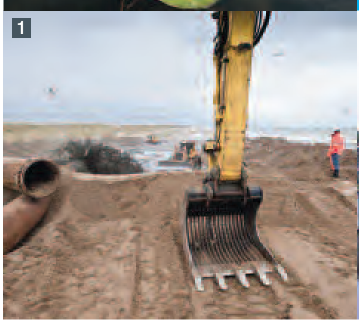
Thus lived the Dutch before two thousand years. Since then, they have struggled and emerged, and now live safe and sound. Against rising sea levels, subsiding soils, and more extreme climatic conditions of floods and droughts. It has been a struggle, but now we realise (again…) that we better learn to live with water than to try and defeat the forces of nature.

The global water reality poses serious and increasing challenges. Today 40% of the world's population is living in water-stressed river basins. As water professionals we experience every day that water is a limited and highly variable resource, involving constraints and risks of too much, too little or too polluted water. But also outside the water sector, the risks of water crises are being noted. The 2015 World Economic Forum's Global Risks report identified water crises as the greatest impact risk facing the world in the coming 10 years. The challenge is huge and fascinating, both for the water sector itself and for related areas. In a vulnerable delta, which the Low Countries by definition and condition still are, water governance is essential. The 23 decentralized and autonomous regional water authorities play a key role in physical existence of the Netherlands. They go under the name of Dutch Water Authorities.

Water management involves much more than building dikes and windmills. It also calls for good water governance, for adapting to climate

DUTCH WATER AUTHORITIES

1: Sand supplementation near Ter Heijde aan Zee, during the reinforcement of the Delflandse Coast.
2: The monumental pumping station Stroink in Vollenhove (Dutch water authority Reest en Wieden)
3: Reed plugs with newly dunes on the beach at Ter Heijde aan Zee.



change, effective water-level control, maintenance of canals and natural water courses and in the treatment of wastewater. Local and regional water management in the Netherlands is largely the responsibility of regional water authorities, which are decentralised and financially self-sufficient public authorities. Regional water authorities are responsible for flood control, water quality and quantity and the treatment of urban wastewater.

In it's report 'Water Governance in the Netherlands- Fit for the Future?' (2014)[1] the Organisation for Economic Cooperation and Development (OECD) qualified Dutch water management as a 'global reference' and praised the effectiveness of Dutch water management and the role of the regional water authorities. The OECD referred to the 'excellent track record' and the 'robust and adjustable institutional and policy framework'.

Dutch Water Authorities also offers an expert platform for bilateral and multilateral cooperation in the field of international water governance. To foster international cooperation between governments, but also in public-private partnerships. In doing so, we contribute to better water management and governance abroad, but also take home valuable experiences from other countries and organizations.

So what is the secret of the Dutch water authority model? Regional water authorities are legally embedded in the overall democratic structure of the Netherlands. They are an independent government body since the year 1255, with their own legal power, tax system and elections. Their primary task is to provide the conditions for good regional water management. Together they are responsible for 18.000 km of dikes (flood protection), 225.000 km of managed watercourses (surface water quantity), surface water quality and 360 waste water treatment plants.

The democratic governance structure is based on the triplet interest-pay-say. Stakeholder democracy is a key value, where residents, industries, farmers/landowners and representative organisations for nature conservation all have their share of influence. The total gross tax revenue of the regional water authorities amounts to a total of €2.7 billion. Half of it is spent on flood protection and surface-water management, the other half on waste-water treatment. Innovation is crucial to keep our water management state-of-the-art, affordable and sustainable. For example, the regional water authorities are cooperating in the 'The Energy and Resource Mining Factory'. A project aiming at the recovery of energy, fresh water and valuable resources from waste water.

Peter C.G. Glas **M.Sc. LL.M. (1956) is chairman of Regional Water Authority De Dommel, The Netherlands. He is also chairman of Dutch Water Authorities.**
He was appointed in 2003 by H.M. Queen Beatrix of The Netherlands to serve as chairman of Water Authority De Dommel. Previously he worked as an environmental consultant and held various management positions from 1983 – 2003 with WL Delft Hydraulics (now Deltares) and the Dutch Ministry of Environment.
www.dutchwaterauthorities.com

Rooted in the strong Dutch heritage of sustainable and adaptable water governance, the Dutch Water Authorities need to constantly revise and renew. We need to stay ahead of the game. Especially in the light of a changing socio-political context with financial constraints and increasing political volatility. So we welcomed the OECD to perform an in-depth and independent reflection on Dutch water management. The global perspective by a high-level think-tank that the OECD provides, pointed out the awareness gap of Dutch citizens as a threat to necessary future investments. Also, the nexus between water management and spatial planning offers room for improvement. And we could strengthen the "polluter/user pays" principle and show higher ambition on water quality policy. So even in The Netherlands there is always room for improvement.

The global water challenge is huge and fascinating, both for the water sector itself and for related areas. The Dutch water authority model, with its origins in the 13th century, is alive and kicking. An ever-renewing heritage we cherish and yet constantly revise. In a country like the Netherlands, both water governance and operational management are issues of 'to be or not to be'.

[1] OECD (2014), Water Governance in the Netherlands: Fit for the Future?, OECD Studies on Water, OECD Publishing, Paris, 275 pp.

4: The pumping station Antlia, a modern pumping station along the Geldersedijk near Zalk.
5: Wastewater treatment plants in Berflobeek (Dutch water authority Reest en Wieden).

APPLICATION OF A 1D2D HYDRODY THE ENVIRONMENTAL QUALITY IN

BY FORTUNATO CARVAJAL MONAR, EISSE WIJMA & ERIK ARNOLD

The Canal del Dique system is located in the North of Colombia. Large scale rectification and enlargements of the cross section in the mid 80's have resulted in a gradual enlargement of the flow capacity of the canal, leading to major environmental and social problems. With the help of hydraulic and topographic/bathymetric data analysis, aerial photographs and the 1D2D hydrodynamic model of the Canal del Dique it was possible to derive measures to start with environmental restoration of the ecosystem of Canal del Dique System.

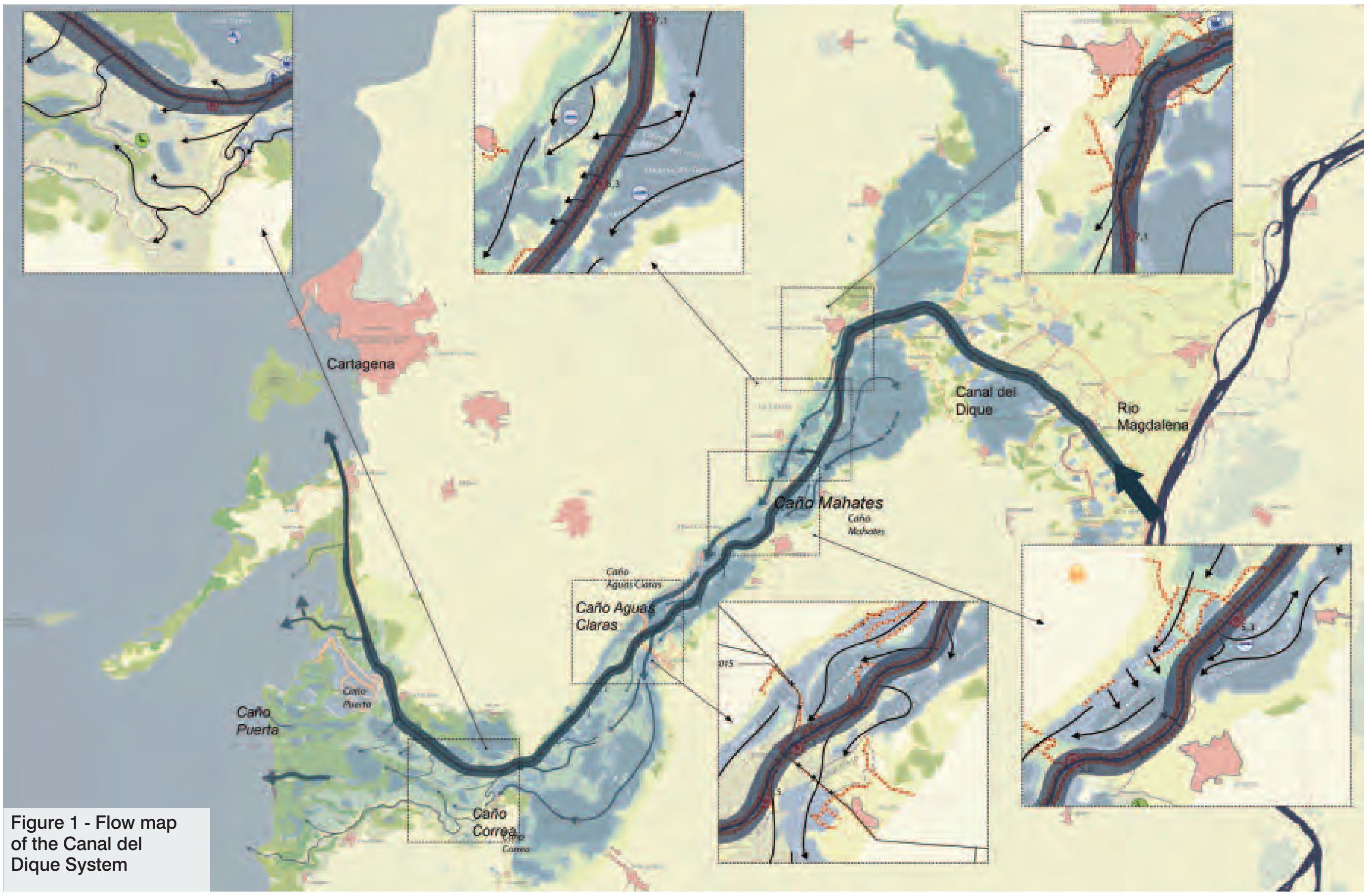


Figure 1 - Flow map of the Canal del Dique System

Historical development

The Canal del Dique is a man-made connection between the Magdalena River and the Caribbean Sea near Cartagena in Colombia. Figure 1 illustrates that Canal del Dique is not just a canal. It is a system of interconnected water bodies (known as ciénagas); the ciénagas drain into the canal via small canals (known as caños).

In old times, the Canal del Dique valley was just a flood plane of the Rio Magdalena. Seasonal fluctuations in river flows transformed the valley, from a cascade of isolated ciénagas in the dry season to one large water body in the wet season. The downstream part of the valley was a tidal salt water lagoon, in open connection with the sea, temporarily closed off by sand bars. The salt water is still found in the deep aquifers, and wells up in times of drought.

In the 17th and 18th century connections between ciénagas were created, starting downstream. Flood water from the Rio Magdalena now concentrated more in these connecting channels, rather than progressing downstream as overland flow. At a certain moment in the past, a permanent connection with the Rio Magdalena was created; this leads to permanent inflow of water and sediment into the Canal del Dique and outflow into the bays of the Caribbean Sea. In the 17th century, the Canal had a more or less meandering pattern. Large scale works in the 20th century cut out most of the meander bends, creating a nearly straight,

NAMIC MODEL TO IMPROVE THE CANAL DEL DIQUE SYSTEM

prismatic canal. The last large construction works were finished in 1984, during which 43 river bends in the canal were cut off, reducing the total length of the canal from about 180 to 117 km. The length of the Canal increases with about 50m per year due to the expansion of a delta in the bay of Cartagena.

The ecological functioning of the Canal del Dique System

Synchronizing behavior

The start of the rainy season initiates changes in both ecology and hydrology. The water levels in the ciénagas start to rise due to direct rainfall and inflow from the Canal. These changes trigger seeds of water- and swamp plants to germinate on the shores and stimulate fish to develop their reproductive organs. The rising waters cause smaller ciénagas to merge and fish to prepare to migrate to their spawning areas upstream.

Water exchange for fish migration:

Fish migration is bound to certain hydraulic conditions. At first, the connection between Canal-ciénaga and the ciénaga-ciénaga connection must be of certain dimensions. The water depth at the connection must be at least 20 cm in order to allow for fish passage, and preferably over 50 cm. The connection must be open in the fish migration season, and it should be active for a minimum period of 5 days with a minimum depth of 50 cm. According to field observations, analysis of aerial photographs and hydraulic model simulations, fish migration is currently low and takes place mainly as a result of caño flow. Bank overtopping seems to occur only incidentally, but is a dominating process for fish migration.

Water exchange for refreshment of water

Refreshment of water in the ciénagas is important for bringing in new nutrients and draining biological or chemical contamination. Most ciénagas show spatially varying refreshment, due to the limited interaction with the canal (only downstream caño connection). Although most ciénagas are in open connection with the canal, circulation of water within the ciénaga is limited to the zone near the caño. Only after bank overtopping, are the more remote areas of the ciénaga (often located upstream) refreshed.

Set up of a 1D2D hydrodynamic model

To derive measures to improve the environmental quality in the Canal del Dique System, a 1D2D hydrodynamic model has been developed for the Rio Magdalena and Canal del Dique. The model is composed of a 1D component describing the main flow in the Canal and the Rio Magdalena; the 2D component describes the overland flow in the Canal del Dique area during high water. The 2D component is important when simulating the 2D behaviour of the system: water exchange from Canal to ciénagas and between individual ciénagas. The 2D model is an extension of the 1D model and adds the floodplains of the Canal del Dique (ciénagas and valley) as DTM to the model schematization. The floodplain elevation has been derived from LIDAR, high resolution and high precision elevation data for the full project area. With the data, it is possible to derive the elevation of all objects in the area with an accuracy of 10 - 15 cm. This way, not only land surface elevation but also the exact surface level elevation of relevant objects, such as elevated roads & dikes, has been included in the hydraulic model. This achieves fitting the canal and

Fortunato Carvajal Monar **has been working for Royal HaskoningDHV on the Canal del Dique System Restoration since 2013 as project director. He received his MSc degree at the International Institute for Hydraulic and Environmental Engineering in Delft, The Netherlands in 1977. Throughout his career, Fortunato has been working as team leader on a number of large-scale river and coastal engineering projects around the world. Examples are the Gorai River Restoration Project, Multipurpose Jamuna Bridge in Bangladesh, the Padma Bridge Phase-1 study, the integrated Meghna River flood control and training works studies, the marine logistic base in the Gulf of Thailand and the integrated flood and bank protection along the Mekong River.**

Eisse Wijma **has been working for Royal HaskoningDHV since 2005. As a project manager and senior expert in river engineering and water management he is involved in many world-wide projects in the field of Hydraulics and Morphology of rivers, deltas and coasts. These include (modelling) studies of river processes, conceptual and preliminary design of coastal and riverfront development and integrated water planning studies (e.g IWRM). Because of his broad experience in water related projects he is able to provide support in projects dealing with the interface between surface water, ground water, ecology and river engineering, which enables him to assure the integration of all disciplines in the projects.**

Erik Arnold **has been working for Royal HaskoningDHV on the Canal del Dique System Restoration project since 2013 as civil engineer. He is involved as a consultant in modelling studies, safety assessments of flood defence and several environmental impact studies. He gained experience in challenging engineering and water management projects, comprising the restoration and rehabilitation of the New Orleans flood defence system in the wake of Hurricane Katrina, dike safety and risk assessment Aqua Blanca Dike along the Cauca River in Colombia, review of river training works in Nigeria and design work for the tender of the Panama Canal Third Set of Locks project.**

ciénagas in one model schematization, something that has not been done before. With the model it is now possible to provide new information about the hydraulic behaviour of ciénagas, an element of the Canal del Dique system which has always remained a very uncertain factor.

Application of the 1D2D hydrodynamic model

Understanding the current hydraulic behaviour of ciénagas is crucial for the definition of ecological system objectives for the system of ciénagas. The 1D2D model has been applied to assess the dynamics of the ciénagas in terms of growing and shrinking. This behaviour is also referred to as "elasticity of ciénagas". The elasticity is determined by the contribution of caño flow, precipitation and evaporation of the ciénagas and overbank flow. These processes are included in the hydraulic model, such that the model enables the prediction of water exchange based on all the relevant physical processes. Figure 2 shows the response of ciénaga Capote to a water level rise of 2 meter in the Canal del Dique. The graph shows the water level as a function of time (hydrograph), starting from low water. At the low water level, the model simulations show that the three ciénagas Tupe, Zarzal and Capote are hardly connected. During high water levels, the system of ciénagas acts like one big ciénaga. This behaviour is also registered by the hydraulic measurements done in these ciénagas.

Another way to validate the model is by using aerial photographs. Figure 3 shows the model result for ciénaga Tupe/Zarzal for the 2011 flood. The locations of overtopping were verified with the overtopping visible in the aerial photograph at the same moment. The analysis illustrates a great similarity between the model and the aerial photograph.

With the 1D2D model and the information gained from aerial photographs, concerning the hydraulic behaviour of the systems of ciénagas in the Canal del Dique system, a flow map was made as shown in Figure 1. The map allows improvements of the connectivity of ciénagas to be determined. These are used as a measure for ecological restoration of the ciénagas.

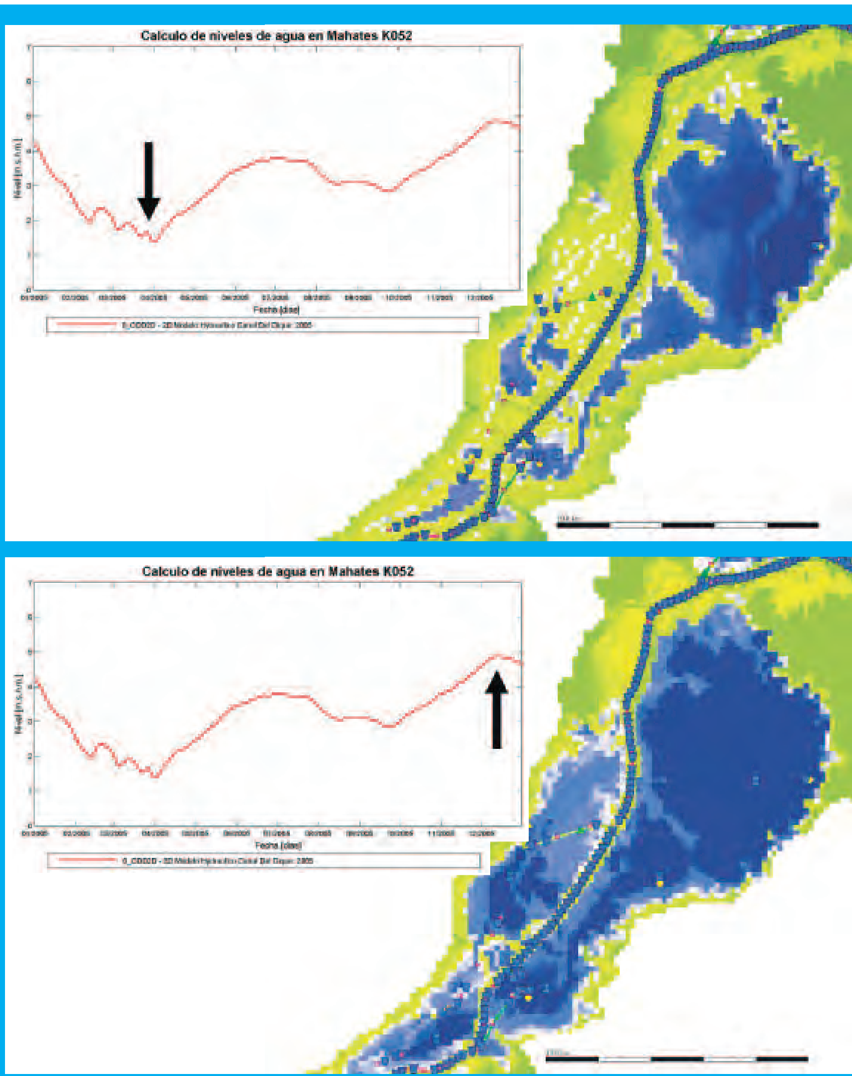


Figure 2 - Visualisation of the elasticity of ciénaga Capote for the May 2012 flood

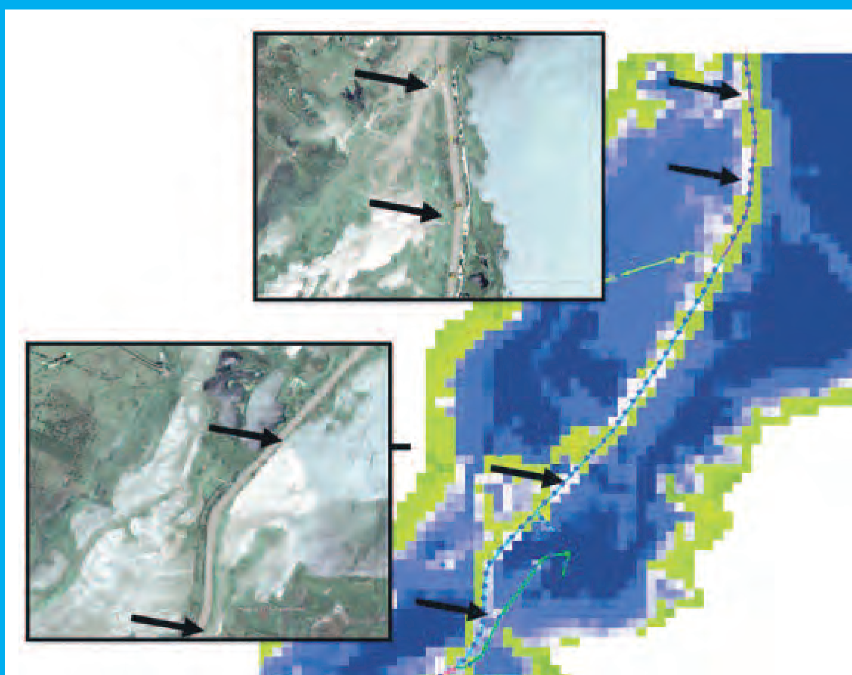


Figure 3 - Model simulation of the 2011 flood, validated with aerial photographs

THE FUTURE FOR IAHR - A PERSONAL VISION

BY ROGER FALCONER

I have been a member of IAHR for about 35 years and over that period I have witnessed considerable change in our discipline. When I first joined IAHR we were studying traditional hydraulics and fluid mechanics per se. Consulting companies were proud of their hydraulics divisions and clients expected the work to be done by 'hydraulic engineers'. At that time we had good links with specialist consulting companies and, in particular, strong ties with the international research laboratories etc. Departments of civil engineering taught hydraulics, hydrology and public health engineering, with the subject topics being taught as almost mutually exclusive. Today things are very different.

Today we are driven by legislation and the challenges associated with climate change, population growth, environmental change etc. The stakeholders - who we now need to en-gage with - are driven by multidisciplinary challenges, such as ecosystems services, the EU Water Framework Directive etc. Take, for example, diffuse source pollution and bathing water quality. The animals on the land deposit FIOs (faecal indicator organisms), the storm comes and the FIOs are transported from the catchment, through the river and estuarine basins, into the coastal bathing waters, often leading to non-compliance with legislation and, ultimately, beach closure. On the other hand the beach could be failing due to point source pollution from an effluent works or CSO etc. Traditional hydraulics forms a crucial part in addressing this beach failure scenario and the expertise within our association has a major role to play in improving: the stream hydraulics, the river hydraulics, the estuarine fluid mechanics and the coastal processes – to mention but a few. Equally hydrology and meteorology are crucial in addressing this problem and so too are aspects of epidemiology, biochemistry, wastewater treatment processes etc. However, whilst we might have expertise to contribute to such problems, we – as an association – are not engaged at the political and key stakeholder levels. No Government comes to IAHR for advice; no international funding agency comes to IAHR for technical support and, in particular, no water industry stakeholders or farming associations come to IAHR for advice for the above example. The same is true - at least in the UK - for research. Our research councils do not come to IAHR for grand challenge initiatives or research proposal reviewers, and our governments (national and regional) do not come to IAHR for the names of prospective members of research panels etc. In my opinion the same is probably true for similar associations, such as: IWA, IAHS, IWRA and PIANC (with whom we have just signed a collaborative agreement). In contrast the Energy research agenda speaks with one voice - at least across Europe. There are much closer links between gov-ernments, NGOs, industry, other stakeholders and the research community. As a result key stakeholders are also more involved and engaged in congresses, such as ours being held this year in The Hague – which I hope you will attend. In contrast to many other disciplines, I would argue that we are a disparate community: including, IWA, IAHS, IWRA and PIANC etc.

My vision for the future of IAHR is that it is paramount that we should work more closely with other water related associations to develop a much stronger collective voice and influence. If IAHR, together with partner associations, can be at the decision making table, whether it be national governments, the EU, UN or the World Bank etc., then we shall have much less difficulty in attracting a wider range of stakeholders to our congresses etc. Furthermore, in this world of growing focus on research impact assessment then we, primarily as researchers, must also welcome closer links with industry and end-users of our research. We have already accomplished much over the past two years on this front by acquiring major sponsorship from Spain Water and IWHR China, both of whom are engaged in a wider range of activities than those historically associated with IAHR; both of these sponsors are driven by a stakeholder agenda. IAHR has also recently become a UN Water partner, which also has the intention of bringing water associations together and we are involved in a new UN initiative on hydrology with UNESCO and WMO.

Roger Falconer **is CH2M Professor of Water Management in the School of Engineering, at Cardiff University. He graduated from Imperial College with a PhD in 1976 and has held posts at the universities of Birmingham (Lecturer, 1977-86) and Bradford (Professor 1987-97). He is currently President of IAHR and a Fellow of the Royal Academy of Engineering. Roger has spent over 38 years pursuing research into modelling flow, water quality and sediment transport processes in river, estuarine and coastal waters. He has published extensively in the field and been involved in a range of international projects.**

In the shorter term (i.e. over the next few years or so), my vision is that we should strive to create a Global Water Society (or similar), wherein the key water associations are affiliated. The Society could have its own president and council, with representatives distributed from the councils of the member associations. I believe that such a Society, which would cover all aspects of water science and engineering, would be attractive to governments, funding agencies and industry, as they would only have one port of call for their issues or challenges relating to water. I believe that if our associations worked more closely together, and spoke and operated with one voice on water, then we would all win and could all contribute signifi-cantly to cleaning up our catchments, rivers, estuaries and coastal basins, in the example cited above. In trying to work towards this vision, Vice President Arthur Mynett and I have already had very positive meetings with the Chief Executive of IWA (namely Dr Ger Berkhamp) and the President of IAHS (namely Prof Hubert Savenije). We discussed with them the opportunities of working more closely together and the benefits of speaking globally on all issues of water through a single voice – a Global Water Society (or similar). VP Mynett and I were encouraged by their enthusiasm to explore this further and our Executive Director and the new Council now have the opportunity to build on these discussions for the future. In the longer term I would suggest that we might even wish to explore the potential opportunities and benefits of mergers with some other associations.

We have seen in the UK the establishment of the Society for the Environment, which includes a number of learned societies all working together. This organisation has, in a very short time, achieved considerable influence in the UK and governments and stakeholders in the field are keen to seek advice etc. from this Society; I believe this Society acts as a tem-plate for the future opportunities for IAHR. My overriding personal vision therefore is that over the next decade IAHR will become a key player in a Global Water Society and international water associations, such as IAHR, can speak with one voice on water issues and together we can develop stronger dialogue with governments, research and international funding agencies, the water industry, consulting companies, NGOs etc. In conclusion, I believe IAHR has a great future, but if we build closer partnerships with similar water associations then I believe we will have an even brighter and more sustainable long term future.

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IAHR AND THE NETHERLANDS – A LONG AND LASTING RELATIONSHIP

BY HENK JAN OVERBEEK


Prof. Thijsse, Prof. Harold J. Schoemaker and Dr. Egbert J. Prins


Prof. Harold J. Schoemaker, Dr. Egbert J. Prins and Prof. Henk Jan Overbeek

For those of you less acquainted with the history of IAHR, it is perhaps interesting to note that IAHR's cradle stood in Brussels where the association was established in September 1935, as an offshoot of the Permanent Association of Navigation Congresses (PIANC). The association's mother tongue at that time was German, with French and English as second languages. Right from the start IAHR aimed for a truly international perspective and hence there was the need for a Secretary-General who was able to easily communicate with all participants and potential members of IAHR. Johannes Theodor Thijsse, Professor at Delft University of Technology and Director of Delft Hydraulics, was elected to the SG position in 1935. In years to come Prof. Thijsse was succeeded by Prof Harold J. Schoemaker (1960), Dr. Egbert J. Prins (1980) and Prof Henk Jan Overbeek (1992). All of us combined our duties as managing director of Delft Hydraulics with the position of Secretary-General of IAHR. After 66 years the Delft-based secretariat moved to Madrid in the year 2001, where it is now hosted at CEDEX with support from Spain Water.

It is not the first time that the IAHR hydraulic engineering community gathers in The Netherlands. In 1955 the 6th IAHR Congress was held in The Hague where some 250 engineers and scientist came together to discuss hydraulic engineering projects. A few years before that time (February 1953) the Netherlands had faced a severe storm surge in the SW part of the country and the country was still in the midst of detailed analyses of what had happened throughout the delta and, more importantly, what should be done to prevent such havocs in future. The final engineering solution – within the framework of the Delta Project – took about 25 years to complete: in 1986 with the closure of the Eastern Scheldt Storm Surge Barrier, and after that the Rotterdam Maeslant Storm Surge Barrier. During the 1955 Congress a photo was taken of all participants and it was possible to recognize clearly friends and colleagues. In these 'pre-selfie' days, this was one of the valuable items to take back home, to be able to show where you had been and whom you had met. At least half a year later you would receive (by surface mail) the printed congress proceedings.

For those of you who are acquainted with the low-lying country of the Netherlands, it should not be a surprise that the main theme of this Congress is "Deltas of the Future (and what happens upstream)", since most of the Netherlands is situated in the delta of the Rhine-Meuse-Scheldt riversystems. More than half of the country is prone to flooding, either by the North Sea or by the rivers, and requires protection by dikes, dunes or barriers to create a safe habitat. Together with the much-needed fresh water discharge from our neighbouring countries Germany, France and Belgium, the rivers also transport a multitude of industrial, toxic and agricultural wastes to the North Sea. A lot has happened since the previous IAHR Congress in the Netherlands. Not only are photographs being replaced by selfies that can be sent straightaway to all over the world, but also printed Congress Proceedings are no longer distributed afterwards by surface mail, but provided onsite on a memory stick or via an app that can be downloaded 'from the cloud'. And the IAHR family has grown from some 400 members in 1955 to almost 4000 in 2015!

But also the problems that we face have changed: global population growth leads to considerable pressures on our water resources, effects of climate change are becoming noticeable, dealing with uncertainties has become a major issue, environmental impact assessments have become an integral part of ever more complex engineering projects. Stakeholders views, multilevel water governance aspects, financial constraints on construction and maintenance have become as much a part of the puzzle as engineering design, spatial planning, biological and ecological issues. Nowadays, engineers are used to work in multi-disciplinary teams to find optimal solutions in close concert with clients and governments. Glancing through the abstracts submitted to this 36th IAHR World Congress, it becomes clear that a large variety of subjects awaits your attention and you can compare notes with a truly global mix of experts and scientists. A challenging week certainly awaits you. Some of the contributions from Dutch colleagues provide intricate details of the two major projects that are presently underway in the Netherlands. The first one is the 'Room for the River' project. It has been on the way since 2008 and most of the 40 projects involved will be completed by the end of this year. The second project is the so-called 'Delta Programme', which will be on its way for at least 30 years to come. It aims at providing a safer environment against flooding, both from the sea and from the rivers. Dikes will be reinforced to better withstand excessive water pressures during high stages and storm surges, spatial planning projects will consider future potential flooding impacts, all to have the country better prepared in the unlikely event of another flood havoc. The Netherlands is committed to remaining to be a safe place to live, work and invest in, despite the potential floodrisks. The latest scientific insights and most modern technologies are used in order to guarantee high safety standards now, as well as in future.

Looking forward to welcoming you on Monday 29 June 2015 in The Hague, the Netherlands!

**Henk Jan Overbeek is honorary Chair of the IAHR2015 Advisory Board.
Member National Advisory Committee Water Governance.
Past Secretary-General IAHR.
Past dean faculty of Civil Engineering and Geosciences, TU Delft.
Past managing director Delft Hydraulics.**

TOPSECTOR WATER: CLEAR GOALS FOR DUTCH WATER SECTOR

BY HANS HUIS IN 'T VELD

The history and prosperity of the Dutch nation are closely linked with water. Large areas of the Netherlands have been reclaimed from the sea and two-thirds of the population of the country would regularly flood if it were not protected by a system of dikes and storm surge barriers. Since the Dutch water sector holds a strong international position with opportunities for continued growth, it has been designated a Top Sector by the Dutch Cabinet.

'That means that the government will make specific investments in the sector, together with companies and the science sector', says mr Hans Huis in 't Veld, chair of the Topsector Water Committee. His team is composed of scientists, top governmental officials, an innovative entrepreneurs from both the SME sector and large companies and an icon from the sector itself, Mr Hans Huis in 't Veld, who serves as a liaison and looks after the implementation of the action agenda. 'The topteam provides advice on measures to be taken by companies, scientists and the government in order to resolve the bottlenecks in the sector and stimulate growth and innovation. Recommendations and a plan of approach are outlined in the action agenda for three pillars: Delta-technology, Water-technology, and Maritime-technology. Several working groups have been established to realize specific targets for each of these pillars.' In addition there are working groups for the human capital agenda and the export and promotion.

Clear goals

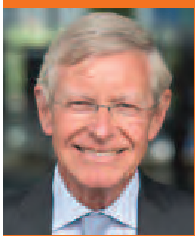
The goals of the topteam are clear: The international market is large and growing rapidly: our main goal is to double the added value of the Dutch water sector in the period leading up to 2020. We want to position the Netherlands as a worldwide leader in the fields of delta, maritime and water technologies. Our water sector has all the ingredients necessary to realise that.

To speed up the implementation of innovations to create new business opportunities the topteam water promotes the cooperation between research institutes (both universities and applied research, like Deltares and Marin), companies and government. Urban deltas all over the world are confronted with a lot of challenges, like flood protection, clean drinking water for the fast growing population, expansion of seaports into the sea, but also feeding the cities. These challenges ask for new innovative solutions.

International cooperation

The top team also focuses on the growth of international cooperation. 'For example: the supply of fresh water available to consumers is gradually diminishing. The Netherlands seeks to anticipate this trend by exploring sustainable solutions to flooding and freshwater shortages. In close cooperation with international partners, for only together we will be able to resolve the challenging water issues of the near future.' The approach for a new plan for the protection and development of the city of Jakarta is another good example of the joint approach of Topsector Water.

Dutch knowledge and technology, developed to produce drinking and industrial water of the highest level, is applied and sold worldwide
Below: The Netherlands is the maritime centre of Europe and is home to one of the strongest and most complete maritime clusters in the world



Hans Huis in 't Veld (1947) **graduated as a coastal engineer from Delft University of Technology. At this moment Hans is Chairman of the Dutch Topsector Water, an umbrella organization for the Dutch Maritime sector, the Water technology sector and the Delta technology sector, with the aim to improve innovation and export through a close cooperation between private companies, knowledge institutes and government. Besides his role at Topsector Water, Hans is member of several Supervisory Boards / Advisory Boards: NV Westerscheldetunnel (Supervisory Board), E.ON Benelux Holding BV (Supervisory Board), Allseas Group (offshore) (Advisory Board) and SNV (Supervisory Board).**

THE NEW DELTA FLUME FOR LARGE-SCALE TESTING

BY MARCEL R.A. VAN GENT

The new Delta Flume in Delft was constructed to facilitate large-scale physical model testing. The new Delta Flume has a length of about 300m, a width of 5m and a height of 9.5m. The maximum significant wave height that can be generated is about H_s = 2.2m and maximum individual wave heights in the range between H_{max} = 4m and 4.5m. This unique facility enables physical modelling at prototype-scale or at close-to-prototype scale. Preventing or diminishing scale-effects is especially important for coastal structures in which sand, clay, grass or other natural construction material is being applied. Besides projects with dikes and dunes, structures such as breakwaters, bed protections, monopiles, offshore wind farms, and storm surge barriers are scheduled to be tested. Along with new facilities also new measurement techniques have been developed, both for the new Delta Flume and for the other wave facilities (*e.g.* wave basins). The new Delta Flume completes a set of wave facilities for physical model testing consisting of small and large-scale test facilities and 2D (wave flumes) and 3D (wave basins) facilities.

Introduction

To determine the response of coastal structures such as dikes, dunes, dune-revetments, breakwaters, cobble & gravel beaches, intake & outfall structures, offshore windfarms and bed protections, under loading of waves and/or currents physical model testing is an essential part of the design and evaluation process of such structures. Some aspects require modelling at a large scale since the materials and/or physical processes cannot be modelled properly on a small scale using Froude's scaling law. Examples of materials that cannot be modelled properly at a small-scale are sand, clay, grass or natural construction material (*e.g.* brushwood). Physical processes that cannot be modelled properly at a small-scale are often related to flow characteristics that do not scale according to Froude's scaling law, *e.g.* for structures in which laminar (porous) flow plays an important role results may be affected by scale-effects. Nevertheless, tests at small-scale can provide valuable indicative results although for accurate quantitative results large scale models are still

Figure 1 - Examples of projects in the Delta Flume

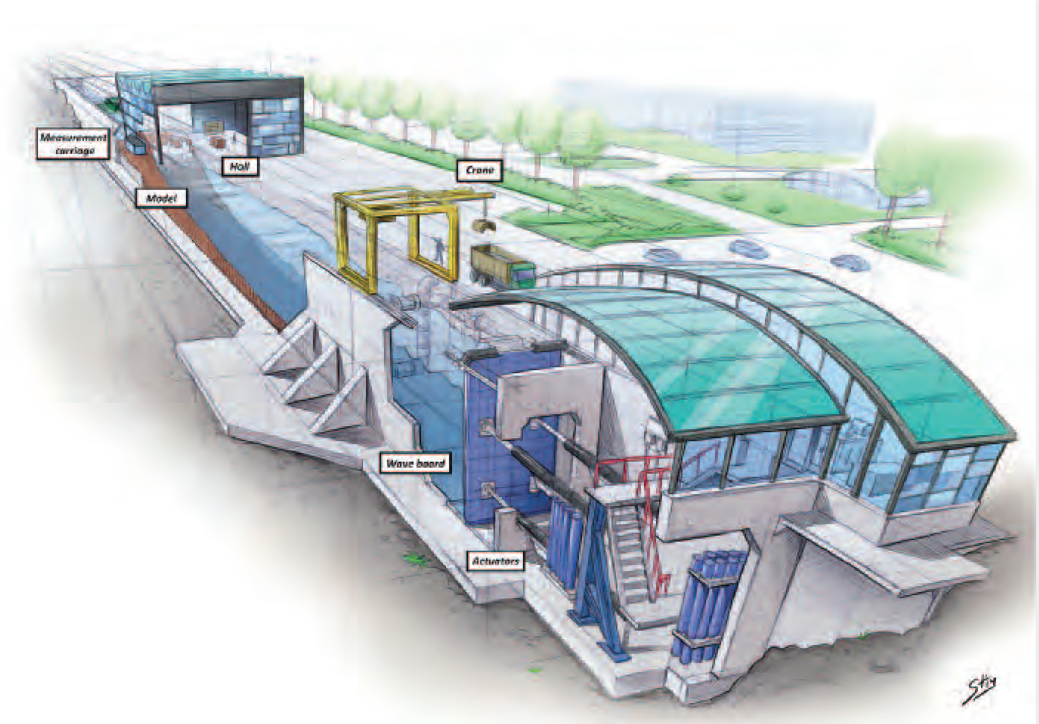


Figure 2 - Impression of the new Delta Flume (courtecy mr Stephan Timmers)

required. Many types of coastal structures can be modelled sufficiently accurate at small scales, e.g. most rubble mound breakwaters.

Besides the scale of models it is important to determine whether the structures can be modelled in a 2D model (wave flumes) or need to be modelled in a 3D model (wave basins). Often combinations of 2D and 3D models are applied, e.g. where cross-sections of structures are optimized in a wave flume, while 3D aspects are studied afterwards in a separate 3D model. Also the combination of small-scale tests and large-scale tests may be an efficient way to determine the performance of coastal structures for those structures in which some of the characteristics would be affected by scale-effects in smaller models. Therefore, it is essential to have a set of small-scale and large-scale facilities available, as well as 2D (wave flumes) and 3D facilities (wave basins). Not only the facilities are important, also the measurement equipment and experienced staff are key factors of the success of physical model tests. In Van Gent (2014) an overview of projects in the various physical model facilities is given.

Projects In The Old Delta Flume

In the old Delta Flume (240m*5m*7m) a large number of projects has been performed in the last 35 years. In these projects the choice for this facility has been based mainly on the need to limit or avoid scale-effects in physical model tests. The new Delta Flume in Delft (300m*5m*9.5m) has been constructed to facilitate measurements at an even larger scale. Figure 1 shows examples of projects performed in the old Delta Flume: Wave impacts on vertical walls, wave overtopping at dikes with grass, the dynamic behaviour of cobble beaches, the stability of placed-block revetments, the residual strength of clay-dikes, breakwater stability, dune erosion, and wave damping by brushwood mattresses. Other typical studies in the Delta Flume are related to for instance the validation of numerical models, testing and calibration of field measurement equipment, and the stability of pipeline covers.

Besides consultancy projects many research projects in the Delta Flume have been performed and resulted in information on the performance of coastal structures, for instance:

■ Placed-block revetments ■ Grass slopes under wave attack ■ Residual strength of dikes ■ Dune erosion ■ Gravel and cobble beaches ■ Wave impacts on vertical walls ■ Geotubes and geocontainers.

The New Delta Flume

The main characteristics of the new Delta Flume compared to the old Delta Flume are that the maximum wave height that can be generated is higher, the length is increased, tidal water level variations can be generated, and the new Delta Flume is close to the other wave facilities in Delft. One of the main advantages of the new Delta Flume over the old Delta Flume is that scale-effects are further reduced; a larger portion of the projects can be performed at (close-to) prototype scale. Figure 2 provides an impression of the new Delta Flume.

Flume dimensions The flume has a total length of about 300m. The size was determined based on tests that have been performed in the old Delta Flume. The modelling area has a total depth of 9.5m for a length of 183m, and an extra 75m section of 7m deep. The deep part has a length that is sufficient to model structures such as dikes while the combination with a shallower section allows for modelling of gentle foreshores over a length of about 250m in combination with for instance dunes. For the majority of the projects the water depth at the wave board will be between 2.5m and 8m. The flume is 5m wide.

Wave conditions The maximum wave heights that can be generated are about H_{m0} = 2.2m and maximum individual wave heights in the range between H_{max} = 4m and 4.5m. The optimal water depth at the wave board for reaching the highest significant wave height for which also the wave height distribution is modelled accurately, is estimated at 6.9m. Spectral significant wave heights larger than H_{m0} = 2.2m can be generated but these will cause some side wall overtopping. Irregular and regular waves, as well as some more special wave conditions can be generated (*e.g.* for

Tsunami modelling and focussed waves). It is expected that irregular wave conditions with standard spectral shapes (*e.g.* Jonswap) will be generated in the majority of experiments, so that during the design of the wave generator emphasis was put on precise specification of this type of wave conditions. Increasing wave height, wave period and water depth require more wave generating power, more wave board stroke and larger flume depths. In Hofland et al (2013) the percentage of water defences in The Netherlands that can be modelled at full scale is discussed. It is estimated that the new Delta Flume is capable of generating sufficiently large wave heights to cover about 85% of the Dutch sea dikes at prototype scale under design conditions. This means an increase in number of Dutch dike sections that can be tested at full scale of about 50% compared to the old Delta Flume.

To generate the large wave heights (*e.g.* $H_{m0} = 2.2$m) with the corresponding wave periods (e.g. $T_p = 9.4$s), a certain wave board stroke is needed. However, waves will reflect from the structures in the wave flume. To absorb these reflected waves with our active reflection compensation system (ARC, see also Wenneker *et al*, 2010), also a part of the wave board stroke is needed. The stroke of the new wave board is 7m, allowing for the mentioned significant wave height in combination with space to absorb waves that are reflected by structures in the flume.

Wave generator To generate the waves that are required a piston-type wave board was selected because of its good performance for coastal applications. The wave board is of the dry-back type. A hydraulic system was opted for. Four actuators are applied to better distribute the forces that the board will experience. The wave generator utilizes Degree of Freedom (DOF) control on the four actuators to accurately control the linear motion of the board while zeroing out unwanted board deflections such as twisting or bending due to hydrodynamic forces and board compliance. The length of an actuator is 24.5m when fully extended.
A novelty in the new Delta Flume is that a tidal variation in the water level is possible by filling and emptying the flume during an experiment. The maximum filling discharge is 1 m^3/s.

Measurements Various measurement techniques are acquired and developed to extract data from the experiments in the flume (Hofland *et al*, 2012). Besides classic point measurements, also synoptic measurement techniques (i.e. high resolution measurements of time-varying spatial fields) have been developed. For the measurements of waves (at the wall) the proven resistance-type wave probes are used. Radars will be used to obtain wave height measurements at any location. In addition, the use of laser scanners and stereo matching of video images can be used to obtain spatially distributed information of waves and/or (deformed) structures. Also good visual observation of the tests is ensured using for instance a central video observation system and many (flush) cavities in the wall near the location of most models to install instruments.

***Marcel R.A. van Gent* is a specialist in the field of coastal engineering, in particular coastal structures, wave modelling, dikes and dunes. He obtained his PhD at the Delft University of Technology in 1995 on the modelling of reshaping rubble mound coastal structures and gravel beaches. Dr Marcel van Gent is now head of the department 'Coastal Structures & Waves' at Deltares, Delft. His is leading a group that consists of about 35 scientists and assistants for performing physical model tests in wave flumes and wave basins, developing numerical wave models, and providing specialist consultancy services. Since 1991 Marcel van Gent participated in various research projects, including projects for the European Union, for the Dutch Government, and in co-operation with Universities, Consultancy firms, and Contractors. Dr Marcel van Gent published about 100 international scientific papers on coastal structures, wave modelling and dune erosion.**

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(a)


(b)


(c)

(a) hydraulic power units for wave generator
(b) crane above flume to construct structures to be tested
(c) blue wave paddle

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PERVASIVE SENSING AND UBIQUITOUS COMPUTING: OPPORTUNITIES, CHALLENGES AND SOME EARLY SUCCESSES

BY VLADAN BABOVIC

The desire to understand the past and predict the future governs the search for laws and models that explain the behaviour of observed phenomena. It is customary today to create computer models of real-world phenomena in order to understand the behaviour of physical and man-made systems.

In oceanographic and coastal modelling, for example, we typically use the Navier-Stokes equations as a model of the world, and apply the forcing terms in form of the evolution of the status of atmosphere (atmospheric pressures and resulting wind fields). Initial conditions describe the sea status (current speeds and directions, water levels) in the entire computational domain at the start of computation. Once the initial conditions and forcing terms are precisely specified, it becomes possible – in principle – to calculate the evolution of the status of the sea from its specified initial conditions as a consequence of the applied forcing.

However, even under ideal circumstances, model results are not precise. After all, every model is just only a model of reality. The equations are derived with the help of simplifying assumptions that inevitably introduce inaccuracies. When we attempt to solve these equations numerically, we discretize modelling domain, and therefore are not able to resolve numerous sub-grid phenomena. Also, the errors in the model parameterization (mainly because many model parameters cannot be directly measured) greatly contribute to errors of numerical models. Finally, it is impossible to precisely define initial and boundary conditions as well as forcing terms across the entire computational domain. All these imprecisions and uncertainties can accumulate to produce fairly unreliable model results despite our best attempts.

At the same time means for data collection, storage, retrieval and distribution have never been so advanced as they are today. Data are collected all the time, everywhere. In addition to traditional fixed in situ sensors that record water levels, light, temperature, pollution and other environmental factors, the proliferation of smart phones and other personal wearable electronics equipped with high-definition video cameras, leads to completely new approaches in crowd sensing of our environment. As a result, the availability of vast amounts of high-resolution spatio-temporal data calls for a new paradigm of enhanced data-model integration. This new paradigm, however, is not without challenges. Big Data in water management are truly big! Data sets in hydro-environment science and engineering today are becoming so large and complex that is difficult to process using traditional data processing tools. There is a host of new issues associated with capturing, curating, storing, sharing, transferring, analysing, and integrating data with models and visualizing final result.

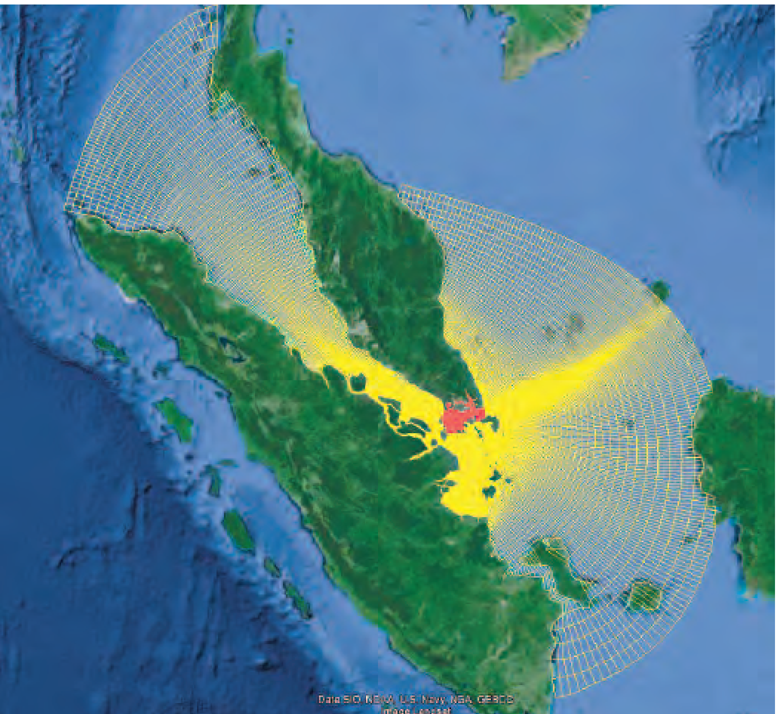
Despite the challenges, the first large scale systems are becoming reality. Having a population density of more than 7,650 inhabitants per km^2, Singapore is one of the most densely populated countries in the world. The island nation has an important coastal environment despite of its small surface land area of 718 km^2. Singapore's coastal waters are heavily utilised for port and shipping activities, maritime and petroleum industries as well as for fisheries, aquaculture as well as recreational activities. There is justified concern to maintain good coastal water quality for recreation and fisheries, supporting ecosystem health, and preserving mangroves, sea-grass beds and coral reefs.

Recently, Singapore's National Environmental Agency (NEA) initiated a real-time water quality monitoring programme to support the Singapore Government agencies in the management of the coastal waters – the so-called Project Neptune. Project Neptune is based on developing a monitoring network made up of eight smart water quality monitoring buoys, equipped among other equipment with automatic wet chemistry laboratories, and strategically deployed around Singapore's coastline. The buoys communicate wirelessly with a high-performance computing facility where the data are curated, processed, archived and then blended with meteorological, hydrodynamic and water quality models resulting in an operational real-time forecast service. Data and model results are disseminated through a thin client to end-users who can access, interrogate and visualize the information through tablets and smart phones. This is probably the first pervasively sensed and ubiquitous model of a national coastal environment in the world!

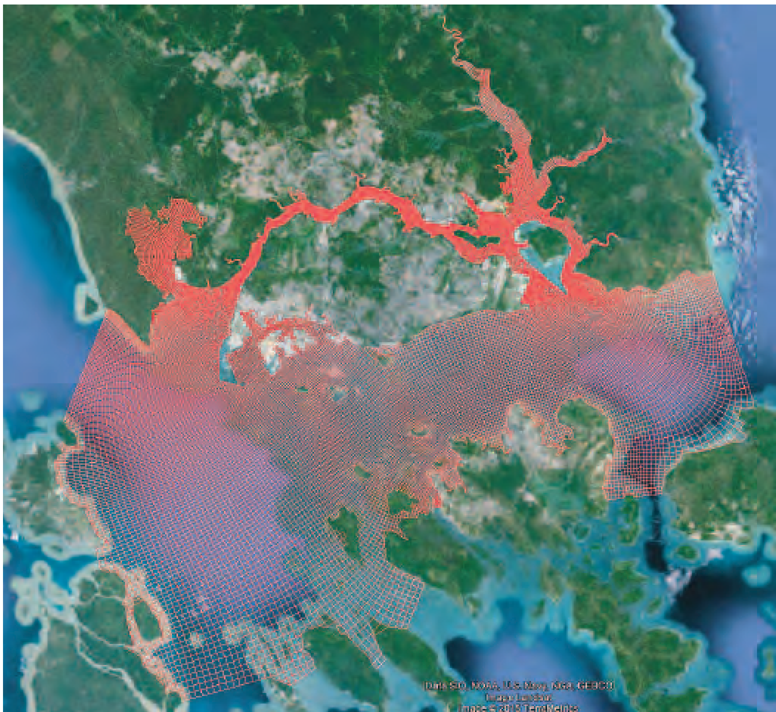
***Vladan Babovic* (National University of Singapore) is a leading scientist in the field of hydro-informatics where he has been spearheading research in data-driven modelling research from early 1990s. In more recent years, his work on flexibility and real options pertaining to decision-making under deep uncertainties in water- and climate-related domains gaining wider recognition.**

Professor Dr. Vladan Babovic is Fellow of International Water Association (IWA) and recipient of IAHR Ippen Award.
In recent years he lead the efforts in securing the funding, establishment and growth of two research institutes: Singapore Delft Water Alliance (SDWA) and NUSDeltares, for which he served as the founding Director. Under this leadership, both SDWA and NUSDeltares were recognised in March 2015 by prestigious Winsemius Award.

Convergence of wireless technologies, advanced monitoring, Internet and computational capabilities is upon us. This convergence provides a backdrop for a new paradigm of pervasive sensing and ubiquitous computing that will allow us to better understand natural and infrastructure systems affecting the environment. The paradigm enables creation of new versatile water management modelling instruments that provide support not only for crisis management, but also for daily operation and decision-making processes, as well as dissemination of information to the public.



Computational Domain of Singapore Regional Model)



Computational Domain of Singapore Island Model

FLUID MECHANICS OF OIL SPILLED
THE ROLE OF CHEMICAL DISPERSA

BY E. ERIC ADAMS, SCOTT A. SOCOLOFSKY AND MICHEL C. BOUFADEL

A silver lining in the Deepwater Horizon oil spill tragedy that occurred five years ago in the Gulf of Mexico has been the opportunity to better understand various physical, chemical and biological factors affecting oil transport and fate. Fluid mechanics has played an important role in this understanding.

Examples include (i) use of PIV-type analysis of video images to estimate the oil flow rate at its source; (ii) theoretical and experimental approaches to predict oil droplet sizes; (iii) laboratory and mathematical models of varying complexity to study the interaction of multi-phase plumes with ambient currents and stratification; (iv) studies of turbulent mixing, dissolution/degradation, and sediment-oil interactions of rising oil droplets; and (v) the capabilities of 3D circulation and transport models to predict Gulf-wide impact. Here we focus on the role of fluid mechanics in helping to determine the effectiveness of subsea injection of chemical dispersants.

Chemical dispersants

As part of the spill response, nearly 3 million liters of chemical dispersant were applied at the spill source, the first time in which dispersants had been used in this manner at a major oil spill. [Figure 1] Dispersants reduce interfacial tension (IFT), allowing smaller droplets to be formed than would be the case otherwise. This, in turn, allows droplets to be broadcast more widely, and to rise more slowly, reducing impacts to rescue workers and biota on the surface and the shoreline. Coupled with their greater surface area, this also leads to greater rates of dissolution and degradation and, over time, less toxic oil in the environment. On the other hand, there is some evidence that chemically dispersed oil and some dispersant compounds are toxic to some marine life, especially early life stages (NAS, 2013). Hence it is helpful to have a clear idea of just how effective dispersants are—i.e., how much they reduce droplet size and how much this matters—so that their use can be optimized.

E. Eric Adams **is a Senior Research Engineer with MIT's Dept of Civil and Environmental Engineering.**

Scott A. Socolofsky **is an Associate Professor with Texas A&M University's Zachry Dept of Civil Engineering.**

Michel C. Boufadel **is a Professor at the New Jersey Institute of Technology's Dept of Civil and Environmental Engineering.**

The three are members of an American Petroleum Institute research team evaluating models of subsurface dispersant injection.

Modeling droplet sizes

Under the highly energetic environment of a blowout, droplet sizes are determined from a combination of droplet break-up, due to turbulent fluctuations in pressure, and coalescence due to droplet collision. For decades, chemical engineers have studied such processes under equilibrium conditions, such as a stirred reactor, and developed correlations of characteristic droplet size with the non-dimensional Weber number, which involves density, IFT, a velocity scale and a length scale. However, oil emanating from a blowout is not in equilibrium, but instead experiences decreasing turbulence along the buoyant jet trajectory. Two modeling approaches have been taken to address the dynamic conditions in a jet. The first approach calibrates observed droplet diameters, measured in laboratory experiments with oil jetted into seawater, to the Weber number using the orifice diameter and velocity as length and velocity scales, respectively (e.g., Brandvik, et al., 2013; Johansen, et al., 2013). Modifications have also been made to account

Figure 1 - Dispersant applied near the source of the blowout

FROM A DEEP OCEAN BLOWOUT: NTS

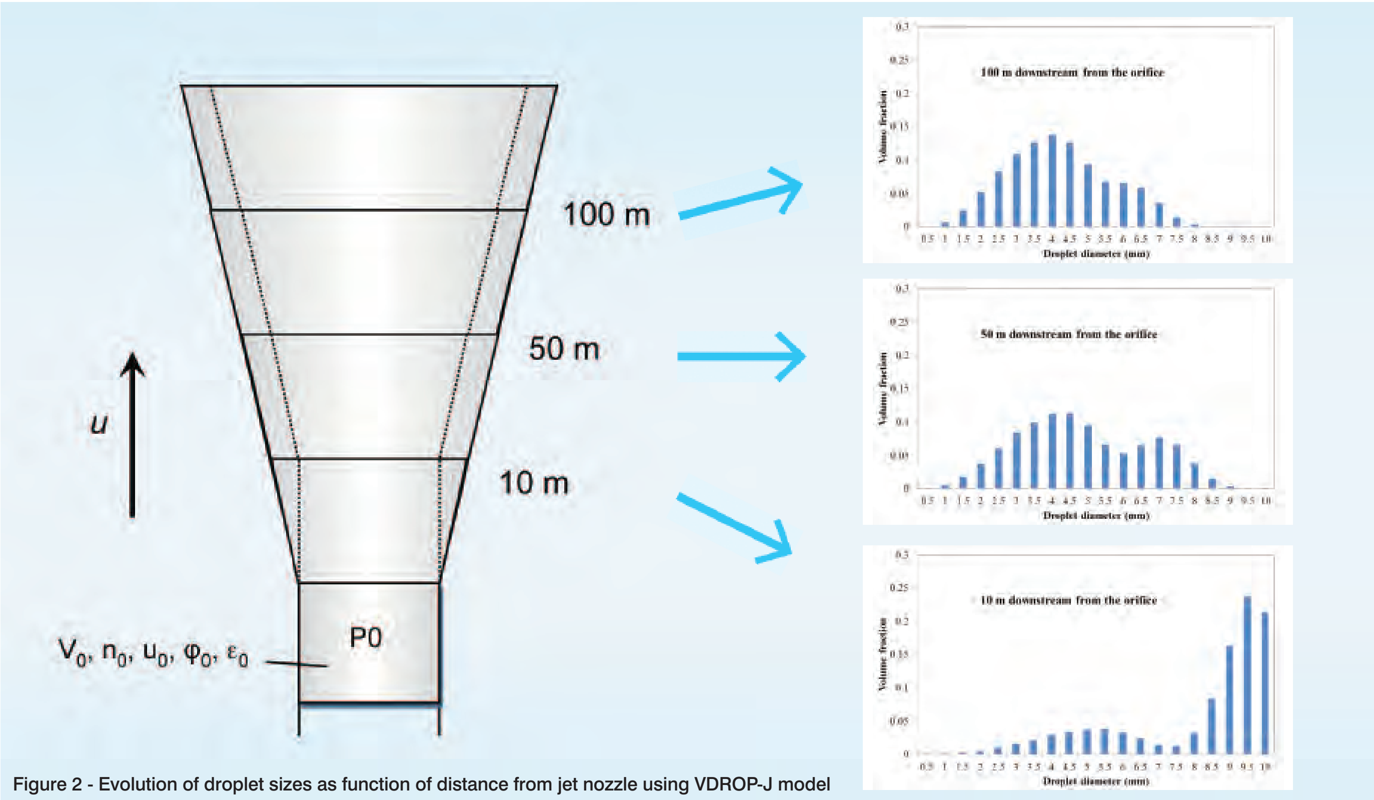


Figure 2 - Evolution of droplet sizes as function of distance from jet nozzle using VDROP-J model

for viscosity (which becomes important when IFT shrinks due to use of dispersants), and the presence of natural gas mixed with the oil. Predicted median droplet sizes from these jet-based correlations agree well with a wide range of laboratory experiments and one small-scale field study, and provide a hopeful method to extrapolate to the scale of a major blowout. They also provide much better agreement with experimental data than correlations based on measurements from a stirred reactor (e.g., Aman et al., 2015). The other approach is use of a dynamic model which simulates droplet breakup and coalescence as oil experiences time-varying turbulence along its trajectory. Recent developments in this field have been captured in the population-based model VDROP (Zhao et al., 2014a), which accounts for the effect of both IFT and oil viscosity in resisting breakup. Zhao et al. (2014b) coupled VDROP to an analytical buoyant jet model and developed the model VDROP-J, whose predicted droplet sizes have been successfully calibrated to available data. [Figure 2] Other models to predict the evolution of the droplet size distribution have been reported by Bandera and Yapa (2011).

A recent model inter-comparison workshop brought together a number of modelers to inter-compare predictions of droplet size and transport for a number of specified test conditions (Socolofsky, et al., 2015). For a large size spill (approximately one third the flow rate of the Deepwater Horizon spill), most models predicted droplet sizes ranging from 1-10 mm without dispersants, and 0.1 to 1 mm if dispersants were uniformly mixed with the oil at a dispersant to oil ratio of 2%. There are still some remaining questions that are being addressed with on-going experiments, such as the effects of using live oil (containing gas), and the dependence on temperature and pressure. Nonetheless, models were in general agreement that the predicted reduction in droplet size and corresponding reduction in droplet rise velocity, could be expected to result in more than an order of magnitude increase in the downstream length to the surfacing oil footprint, a significant measure of the effectiveness of subsea injection of chemical dispersants.

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THE GENESIS OF IAHR-YPN DELFT – THE STORY BEHIND

BY VERONICA MINAYA

Often good ideas emerge after an inspiring conversation, and the creation of IAHR-YPN Delft is a clear example of that. The first seed was planted some years ago when Professor Arthur Mynett, IAHR Vice President and Chair of the IAHR2015 Local Organizing Committee, took the initiative to probe the interest amongst PhD students at UNESCO-IHE to set up a 'Delft Chapter'.

IAHR YPN Young Professionals Network
Supported by Spain Water and IWHR, China

Yared Abebe (left), Veronica Minaya (middle) and Maurizio Mazzoleni

The city of Delft is known for its nicely preserved historic center with canals and medieval churches

© Vanbeets | Dreamstime.com - Tourist Boat In Delft Photo

At the IAHR 35th World Congress in Chengdu, the idea of having a young professional network in Delft grew even stronger and during my visit to Porto for the 3rd IAHR Europe Congress I met an enthusiastic group of young representatives of already well-established networks in a cooperative IAHR platform. Sparked by the many good examples of other strong and experienced YPNs, we approached a number of young professionals from the various institutes in Delft.

We formed a group of youngsters eager to set up a network in Delft. A couple of weeks later we officially established our IAHR-YPN Delft (http://iahrdelft.youngprofessionalnetwork.unesco-ihe.org/home) with members from UNESCO-IHE, TU-Delft and Deltares. We strongly believe this initiative can improve the link between industry and academia and can contribute to the dynamism and cooperation with other networks.

Together with another youth organization – the Water Youth Network (www.wateryouthnetwork.org) – we created an attractive YPN program for the 36th IAHR World Congress in The Hague.

Activities include (i) speed networking, where YPs meet the leaders of companies in the water sector, (ii) soft-skills workshops, (iii) YPN Forum, (iv) technical tours and (v) evening programs. Our great sponsors for the activities related to the Congress are Boskalis, Van Oord, Rijkswaterstaat, Port of Rotterdam, Deltares and IAHR2015 LOC. The team IAHR-YPN Delft very much hopes to meet you in The Hague and to strengthen the links among our future engineers and scientists in the hydro-environment community! At the latest World Water Forum in Korea (April 2015) we participated in creating a news bulletin every other day, which we will try to do for the IAHR2015 World Congress as well. Please feel free to offer your help and expertise. Looking forward to meeting you soon!

Veronica Minaya **is a PhD researcher at UNESCO-IHE (Delft - The Netherlands) currently working on the quantification and assessment of the ecological services of the alpine grasslands in Ecuador, mainly the carbon storage (how this contributes to global carbon fluxes) and the hydrological regulation through the use of an eco-hydrological model. Her technical background is in Civil Engineering with Msc in Hydraulic design obtained in her home country Ecuador, and a Msc in Limnology and Wetland Ecosystems, attending modules in The Netherlands, Czech Republic, Austria and Kenya.**

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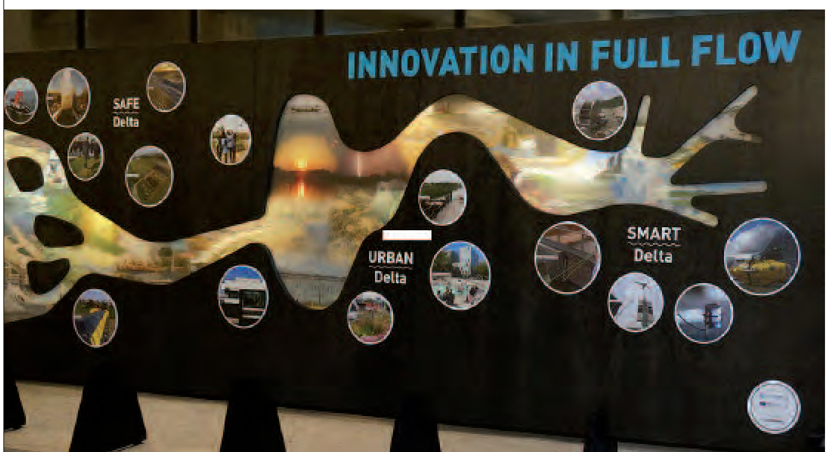

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QUALITY TEAM (Q-TEAM) ENSURES DESIGN QUALITY OF ROOM-FOR-THE-RIVER MEASURES IN THE NETHERLANDS

BY FRANS KLIJN

In the 1990s the Netherlands changed its policy on river flood management, away from recurrently raising embankments and towards making more room for the rivers. In 2006 it was decided to implement 39 measures, which should not only lower the design flood levels, but should also enhance the spatial quality. In order to ensure that this goal was met a Quality Team was established, commissioned to coach the planners, to peer review the designs, and to report to the minister.

Frans Klijn **is senior specialist in applied geo-ecology and policy analysis, working at Deltares (The Netherlands) since 1996. In the 1990s he played an important role in the societal debate on the management of the large Dutch rivers, which culminated in the Room-for-Rivers policy. He is member of the Science Board of Deltares and professor of Adaptive Delta Management at Delft University of Technology, and has been member of the Q-team since its establishment in 2006.**

Room-for-Rivers programme

In the 1990s two major floods triggered a policy change with respect to dealing with river floods, partly inspired by a re-valuation of natural and cultural heritage, but also attributable to the fact that arguments related to sustainable flood risk management were being introduced into the debate, and that alternatives for reinforcing embankments were not only being proposed but also proved feasible (cf. Van Heezik 2008).

After elaborate studies (Silva et al. 2001) 700 individual measures along the three Rhine River branches were solicited and analysed in a consistent manner. These measures were all incorporated in the 'Planning Kit Room-for-the-Rivers'. This supported the authorities and stakeholders to jointly select 39 measures, which lower the flood level over the whole length of the three river branches by about 30 cm. Based on this joint planning effort, the national authorities in 2006 formally decided 1) which measures were to be implemented, 2) what their individual hydraulic effect should be, and 3) that each measure should also enhance the 'spatial quality' of the area.

For the next planning stage the national government preferred local, regional or private parties to take the initiative for the detailed planning and design. Thus the local interests might be better taken into account, the commitment to the plans greater, and the support for implementation larger. Such decentralization, however, also calls for strict constraints on hydraulic effect and budget, and it requires a certain supervision concerning the achievements on enhancing spatial quality.

Therefore, the minister appointed a programme director and staff, and established a Quality Team for the formal supervision concerning enhancing spatial quality. This so-called Q-team

Q-team members assisting the local design team

Nijmegen dike relocation, past (left) and future situation (3-D computer visualisation right). Courtesy: City of Nijmegen & Royal Haskoning DHV

was given the assignment to produce independent recommendation on enhancing spatial quality. The team is chaired by the State Advisor for the Landscape (in the beginning Dirk Sijmons, presently Eric Luijten) and consists of five specialists of different disciplinary backgrounds, all with many years of working experience in the Rhine River delta.

Detailed planning and implementation

The detailed planning started in 2006-2007 and the implementation of all plans is scheduled to be finished by 2015-2016. This means that the role of the Q-team is coming to an end, and that we can evaluate the results both in terms of the quality achieved in the detailed designs, and in terms of the merits of having a Q-team in the planning process.
For us, as team members, this was a reason to share our experiences from an inside perspective in behalf of other flood risk management or landscaping programmes in a paper in the Journal for River Basin Management (Klijn et al., 2013). In that paper we elaborate on our approach and way of working, go into the question of how to understand the concept of spatial quality and explain how we dealt with the issue of design assessment. And we discuss a number of recurrent issues and give recommendations based on over 70 visits to the individual projects. Below, we only briefly reflect on our approach and the merits of having a Q-team.

Informal coaching and formal judgement

As spatial quality, like many other qualities in arts or crafts cannot be measured quantitatively in a satisfactory way, we decided for a combination of coaching and peer review. This approach is common in many arts and crafts (cf. Sennett 2009), which can only be mastered by sufficient practice under the guidance of a skilled tutor. Our first aim therefore was to assist the local project teams and designers in their endeavour. This informal approach requires a good relationship with mutual trust and for a joined purpose: good plans.

In contrast, the Q-team was also commissioned to judge the achievements of the local project teams and to recommend on the acceptance and funding of the plans to the national authorities. This called for a critical peer review and sometimes austere judgments. This is very similar to the process of peer-reviewing of scientific papers, which is the best we can achieve to secure a certain quality standard. This formal approach involves criticizing the work of colleagues, but is always aimed at improvement.

Reflection on the merits of a quality team

Spatial quality is a difficult to understand and to define concept. And assessing the spatial quality of a plan before implementation takes a good deal of imagination, which requires ability to read plans and design sketches. Such skills may be present among experienced people from the same guild or profession. Putting them in a quality team is therefore a good means of achieving design quality.

A quality team can only play the intended role if a number of requirements are met. First, spatial quality should be made an explicit objective. Next, the team should be able to work fully independently with a clear task: of securing spatial quality, and nothing else. This requires that a formal role and competence must be attributed to the team, otherwise it is toothless. The authority responsible for the programme should therefore fully trust the quality team and should always back its judgments and opinions on design quality or spatial quality. This does not preclude that each recommendation should be followed, for authorities obviously have multiple and different responsibilities; they may decide otherwise, for example for reasons such as funding, timely delivery or as a result of negotiations with certain stakeholders.

Most importantly, delivering spatial quality is primarily a matter of the right people. People who are dedicated, have the capability to explain a design to people with very different backgrounds, and are prepared to enter into the long-term commitment required for a complex project. Installing a quality team may help to make that happen, as it supports what one might call a community of practice. It was our experience that in practice the informal coaching produced more design quality than only a formal procedure might have, but that on the other hand this may not have been the case without the formal procedure sustaining it. This double approach thus pays off in the high quality of the designs that are now being implemented.

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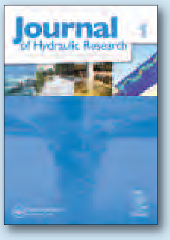

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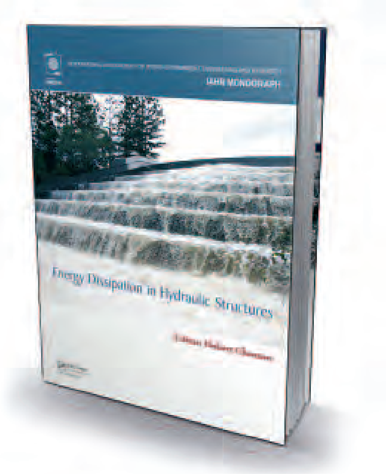

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