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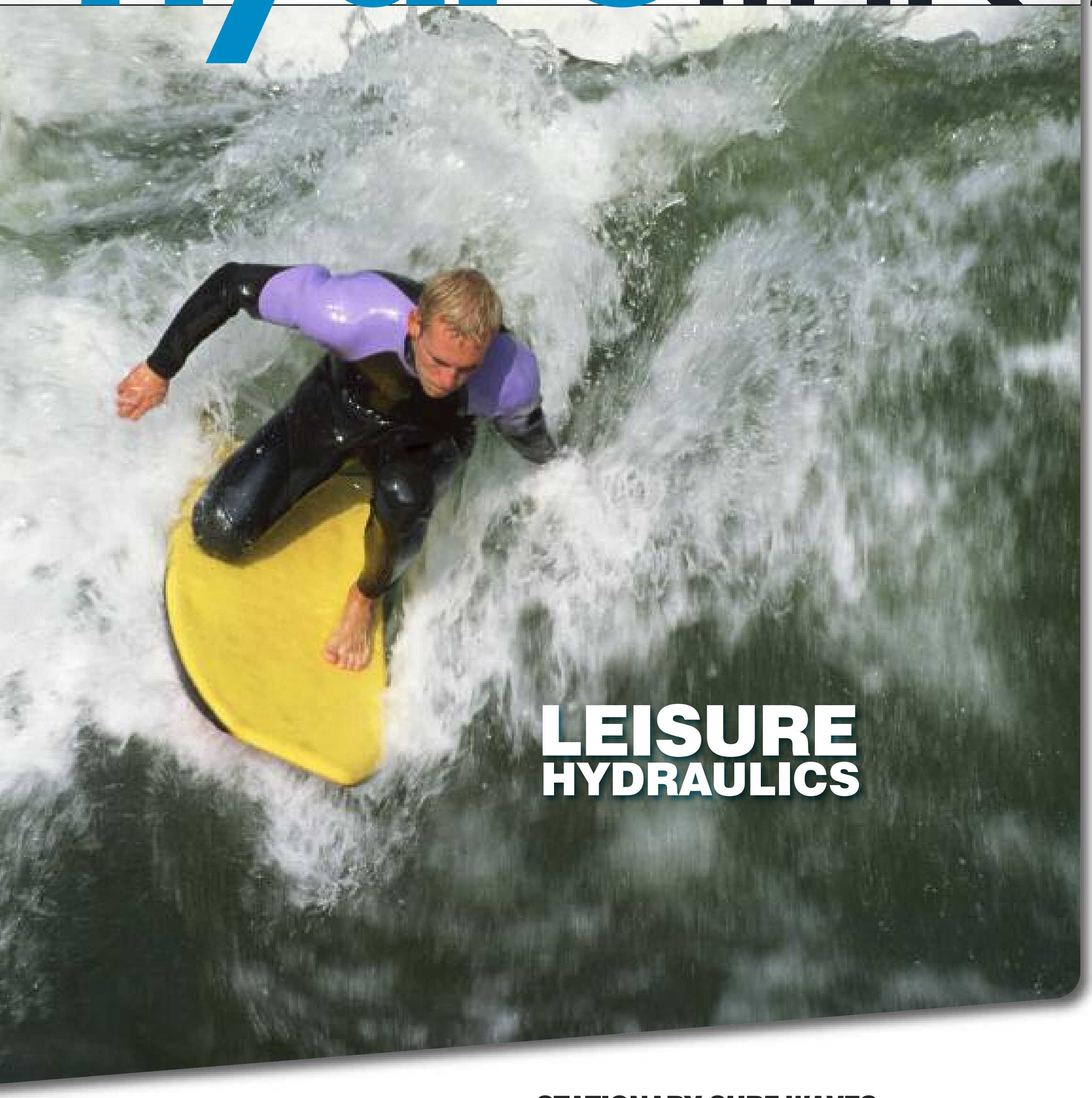

LEISURE HYDRAULICS

IAHR AIRH
International Association for Hydro-Environment Engineering and Research
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HYDRAULIC ENGINEERING IN THE SERVICE OF LEISURE ACTIVITIES

EDITORIAL BY ANGELOS N. FINDIKAKIS

Angelos N. Findikakis
Hydrolink Editor

Even though hydraulic engineering and research mostly supports the design of utilitarian water works and structures, and more recently the understanding and dealing with environmental problems, there is a history of the use of the principles of hydraulics in the service of leisure activities and aesthetic pleasure. Examples are the decorative fountains in ancient Rome, the water features in the Moorish gardens in Alhambra, the elaborate designs of fountains and water basins in France and Italy in the Renaissance, and the many water shows in the twentieth century from Planten un Blomen in Hamburg to Bellagio in Las Vegas.

In the twentieth century, as people in industrialized countries started having progressively more leisure time, the demand for recreational facilities increased rapidly leading to the development of water sports and activities in natural water bodies or in specially designed spaces. The equipment and accessories used in many of these activities has evolved and benefitted from developments in competitive water sports, whose rising popularity attracted sponsors and athletic product manufacturers willing to invest in research and development work that would give elite athletes a competitive edge in their performance. There are numerous examples of such work over the last few decades. Towing tanks in hydraulic laboratories and numerical models have been used for years to develop faster boats for international competitions, such as the America's Cup. In the last twenty years Computational Fluid Dynamics (CFD) codes have been used many times for the design of the hull, keel and underwater appendages of the yachts participating in this event. Similar hydrodynamic studies have been performed for the shape of rowing boats, canoes and kayaks used in the Olympic Games aiming at improving their speed. Numerical simulations have also been performed to analyze and understand the factors affecting the drag and propulsion forces in swimming and the forces on the body of competitive platform divers. CFD has also been used in the design of swimsuits worn by the competitors in the last few Olympics. These swimsuits have helped elite swimmers increase their speed and break many world records [1].

Hydraulic laboratory tests and numerical simulations have also been used for the design of special facilities that allow athletes to train. A recent example, that generated a lot of interest among the general public, is the Surf Ranch, an artificial wave facility in the Central Valley of California developed by a team led by world champion surfer Kelly Slater. The facility which took more than ten years to develop, is about 700 m long and can generate waves greater than 2 m. Solitary waves are generated by a large hydrofoil, designed at the University of Southern California in Los Angeles [2]. This facility has attracted the interest of many professional surfers and is expected to be used in the future as a competition venue for the World Surf League's Championship Tour.

Several smaller facilities with wave generating capabilities that attract many amateur athletes and surf lovers have opened in the last few years. For example, Wavegarden a Spanish company designing and manufacturing wave generating systems has developed its own surfing facilities in Wales and in Austin, Texas, and is planning several new similar facilities around the world. Water parks with smaller wave generating facilities and other recreational water attractions exist in many parts of the world.

The present issue of Hydrolink includes two articles that describe recent research in support of the development of surfing facilities in rivers. The article by Aufleger and Neisch discusses the standing wave formed in the manmade river Eisbach in Munich, which is a major local surfing spot, and describes their work using a combination of physical model tests and numerical simulations to develop a commercially viable technology for generating reliable standing waves in rivers that could serve as surfing venues. The article by Puckert, Mester, Noack and Wieprecht gives an overview of their work with physical and numerical models in support of the conceptual design of a hydraulic structure that would produce surfing waves for varying boundary conditions at the Neckar River in Stuttgart. The issue includes also an article by Ortiz-Angulo Cantos that discusses research in support of the design of submerged structures aimed at improving surfing conditions in the Somo-Loredo beach on the Cantabrian Coast in northern Spain.

As mentioned in the beginning of this editorial note, hydraulic engineering has been used many times to create pleasant and sometimes unexpected environments, where people can relax and enjoy their leisure time. Two such examples are given in the article by Llorca, who discusses the design of the water mirror (le miroir d'eau) in the Place de la Bourse in Bordeaux, France, a thin layer of water formed quickly over a large area which creates beautiful reflections of the surrounding classical architecture buildings. Llorca also describes a similar design for the BJP Billiton water park in Perth, Australia that can be flooded with a thin layer of water and drained within seconds. The article by Segovia-Cardozo, Rodriguez-Sinobas and Zubelzu discusses the hydraulics of the irrigation system of a "living wall" consisting of a large number of different plants in pots arranged on a vertical surface at the Center for Innovation and Technology for Human Development in Madrid.

Both the design of venues for water sports and recreational activities and the use of water to create pleasant environments represent interesting applications of hydraulic engineering, some of which are still the subject of ongoing research.

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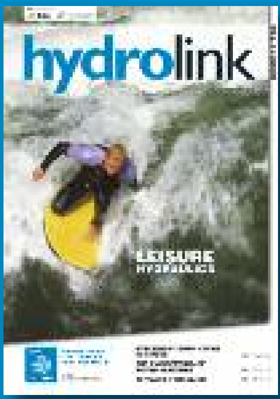

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IN THIS ISSUE

STATIONARY SURF WAVES IN RIVERS

BY MARKUS AUFLEGER & VALERIE NEISCH

Inland surfing is in vogue. There are many stationary river waves currently planned in Austria, Germany and other European Countries. However, the generation of stationary waves that are surfable, attractive and safe is a significant technical challenge, particularly because the apparatus, generating the waves has to be adjustable due to the changing hydraulic boundary conditions. The effective design of these structures requires sound scientific investigations.

Surfing is more than just sport – it is a lifestyle! In many coastal regions, waves, created by complex hydraulic processes, are the foundation for tourism and the way of life. The attraction of surfing is in the sport itself, which can be addictive, and in the surroundings in which it takes place. This charm captivates also many people living far away from the coast. They want to surf despite the lack of local waves! Therefore, they have to travel, typically during holidays or weekends. Because of this interest, significant ongoing activities focus on ways to expand surfing in inland regions to make it possible away from the coast to enjoy surfing daily after work. This creates by the way an important new inland surf market.

For inland surfing a distinction must be drawn between big surf pools, where mechanical devices and pumps are used to generate waves similar to those of the ocean, and stationary surf waves. The latter can be created in artificial environments equipped with strong pumps or in rivers by making use of the natural slope. In terms of energy consumption, carbon emissions and investment costs, surfing on river waves has significant advantages.

Until now, the most well-known inland standing wave is formed by the Eisbach in Munich, Germany. Here an artificial river forms a nearly 1m high standing wave, which has become a popular river surfing spot. This wave is the result of a combination of the non-optimal hydraulic design of a conventional stilling basin, a unique stationary flow (controlled steady channel flow) and some additional stabilisation measures performed by the local surfing community. The Eisbach Wave is an excellent example of the socio-economic benefits of standing waves. Everyday this spot is busy with many surfers and even more spectators (Figure 1).
It has thus become a magnet for locals, tourists and surfers from all over the world.

Even though this spot was originally not intended to end up as a legendary surfing spot, the ´Eisbach Wave´ can be considered as an archetype for artificial standing waves. It remains important to point out, that the hydraulic boundary conditions at this artificial river differ very much from a natural river system with changing flows.


Figure 1. Surfing at the Eisbach in Munich. Photograph: Valerie Neisch

The hydraulic theory of energy dissipation describes the occurrence of stationary standing waves ([1] [2]). In hydraulic engineering works, stilling basins are built to dissipate the energy of the flow downstream of a barrage, a weir or a dam. The principle aim in the hydraulic design of stilling basins is to achieve adequate energy dissipation through a stable and fully developed hydraulic jump, which must be formed effectively and close to the drop rather than moving downstream. After leaving the stilling basin, the water flows calmly. This is the goal of engineering design.

The area near a hydraulic jump is dangerous. If a person unexpectedly gets into a hydraulic jump, the consequences could be life threatening [3]. The near-surface current is very strong in direction of the upstream side and it can become impossible to escape the roller.

Stationary standing waves are unwelcome nearby weirs and other hydraulic structures. The energy of the flow downstream is much higher in comparison to a regular hydraulic jump and as a result, riverbed erosion can increase. Apart from that, despite the rough visual appearance of the flow, there is relatively very little risk for a person to get stuck in these waves. However, a wild but harmless standing wave can veer rapidly into a deadly roller triggered by a minor change in the hydraulic boundary conditions.

Although it is not always easy to avoid stationary standing waves in traditional water construction projects, creating stable, surfable waves is a challenge. There are numerous examples of unsuccessful attempts to create surfable waves by adding or by moving boulders in the riverbed. Sometimes waves do not develop at all,

Figure 2. Physical model test at the University of Innsbruck, 2018 (Dreamwave – concept). Photograph: Marco Schuster

sometimes they occur for a very limited range of discharges, and sometimes they disappear as soon as there is a very little change in the hydraulic system (e.g. a little rise of the tail water level due to local sedimentation processes).

Together with a private company, the University of Innsbruck carried out a number of physical model tests (Figure 2) and numerical simulations in order to develop a commercially viable technology to develop reliable standing waves in rivers.

The basis of this patented technology is a device, which controls the upstream water level whilst ensuring an appropriate geometry for the generation of waves if needed. By implementing an adjustable wave structure, it becomes possible to generate waves of different sizes, shapes and surf levels, which are surfable for beginners and advanced.

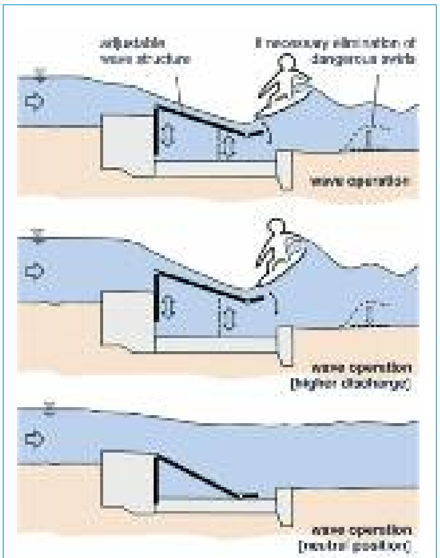


Figure 3. Adjustable wave structure (Dreamwave – concept)

This device makes the creation of river waves under changing natural hydraulic conditions possible. The bigger the specific flow, the higher the difference between the upstream and downstream water level has to be in order to get a stable stationary standing surf wave. Apart from that, in any position during wave operation the basic geometry corresponds to a flat ramp, which ends in an abrupt drop (Figure 3). Downstream of this drop a ´natural´ wave, without any structure below, develops. An additional ´kicker´ fixed at the end of the ramp ensures the appearance of a standing wave. The adjustable wave structure can also be lowered outside the wave operating hours in order to ensure free flow conditions. River wave structures can be implemented directly in the river course or – for more advantageous in terms of operation – in a river diversion (Figure 4).

These structures have to operate in a safe and reliable way and the requirements for design, construction and reliability of these devices correspond to those of traditional hydromechanical steel structures. Recent technological enhancements include two or more adjustable wave structures side by side (module ramp).

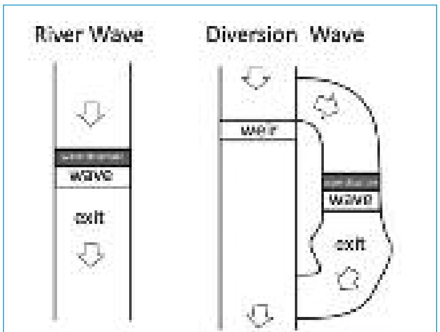
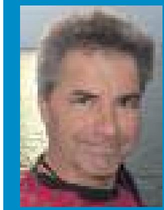
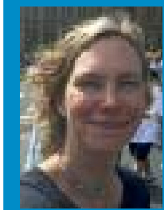


Figure 4. River wave concepts – different plan view situations



Prof. Dr. Markus Aufleger is since 2007 full professor and head of the unit of Hydraulic Engineering at the University of Innsbruck in Austria. He has been manager of the Laboratory of Hydraulic and Water Resources Engineering of the Technische Universität München from 2000 to 2007. He is working in the fields of dam engineering, river engineering, hydropower and water resources engineering. Markus Aufleger is active member of several professional organizations. Besides, he is co-founder of the Dreamwave Holding GmbH, Cologne.



Valerie Neisch is research engineer at the University of Innsbruck. Together with a colleague she is managing the laboratory of the Unit of Hydraulic Engineering. Here from 2013 to 2016 she was very much involved in the scientific investigations for a surfing spot at the river Isar in Munich by running a large physical model.

This arrangement increases the range of usable flows for wave generation due to the possibility to block parts of the cross section during low water conditions. Additionally it becomes possible to create spatial effects in the stationary standing wave by steering the modules individually. This capability turned out to be extremely attractive for the target groups, surfers and kayakers. For the successful development of these structures the collaboration between hydraulic engineers and professional surfers was of the utmost importance.

Despite the high number of ongoing projects and the remarkable engagement of the surfing community, the number of river wave projects that have been completed so far is very limited. The restraining factors are generally the investment costs, water permits, ecological issues and the liability risk. In spite of these challenges, a very colourful community consisting of surfers, kayakers, tourist experts, local politicians and last but not least hydraulic engineers are developing a number of exiting, artificial surf spots in rivers. ■

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NECKARWELLE: A RIVER SURFING WAVE FACILITY IN THE HEART OF THE CITY OF STUTTGART

BY D. K. PUCKERT, B. MESTER, M. NOACK & S. WIEPRECHT

Experiencing the joy and excitement of riding perfect waves is the dream of many surfers living far from the sea. In Stuttgart, this dream could soon become reality with the installation of a stationary wave in the River Neckar. To find the optimal hydraulic conditions, the flow of the river is replicated both experimentally and through numerical simulations. The results of these investigations will be key elements in the design of the perfect river wave.

Figure 1. Rendering of prospective Neckarwelle

Why river surfing?

Today, the pleasure of riding waves and the thrill of feeling the powers of nature has made surfing one of the most popular and fastest growing sports. Meanwhile, there are millions of 'land-locked' surfers in continental regions, relying on flights, or long trips to coastal areas. At the same time, the best spots become increasingly crowded and visitors often struggle to compete against highly skilled local surfers. The lack of surfing opportunities has initiated artificial 'wave' projects in water parks [1], indoor leisure sites [2], wave pools [3] or even barreling wave machines of the size of a football stadium [4]. A more economic and environmentally friendly approach is to use the natural power of rivers to create a stationary wave. A well-known example is the Eisbach River in Munich, Germany, which attracts thousands of tourists every year.

In Stuttgart, Germany, a group of surfers and scientists are investigating the opportunity of installing a surfable wave in the Neckar River. The prospective Neckarwelle ('Neckar wave') will be situated in the vibrant area of Untertürkheim in Stuttgart. The scenery around the proposed wave area is beautiful and the wave would fit naturally to this spot, where swimming, rowing and kayaking is already offered [Figure 1]. A map of the location is shown in Figure 2. The wave is not in the main channel of the Neckar River itself but in a diverted side channel, which carries the majority of the flow. A hydraulic power plant is located upstream of the wave and represents an important aspect of the design of the wave facility. This side channel is advantageous as it is not used for navigation and it offers protection for the wave facility from extreme flows and

Figure 2. Map of Neckarwelle location

floating debris. The difference between the headwater and tailwater level at the power plant is 3.6 m with approximately 1 m of head being required to operate the wave.

The science behind river waves

In ocean surfing, the surfer moves along with a propagating shallow water wave until it breaks. In contrast to this, river waves are created by a hydraulic jump. The working principle is sketched in Figure 3. To carry the weight of the rider, the surfboard requires a sufficiently high flow velocity and a certain gradient of the water surface. The required velocity is achieved by impounding the water level upstream of the wave and then guiding the flow in the streamwise direction down a ramp with a short deflector at its end. Physically speaking, potential energy is accumulated by increasing the level of headwater and then converted into kinetic energy at the location of the wave. The velocity at the wave trough is in the order of 3.5 m/s, yielding Froude numbers in a range of 1.5 to 3. A hydraulic jump forms closely downstream of the wave, where the supercritical flow conditions are transformed into subcritical flow conditions. A result of the pressure increase due to the hydraulic jump is the formation of a recirculation zone with a rotating vortex below the layer of supercritical flow. This recirculation zone has a significant impact on the formation of the wave and on the safety of the surfer [5]. At constant inflow conditions, this phenomenon is stationary and the result is a standing wave [6]. However, only the maximum wave, a specific type of hydraulic jump, can be surfed. The maximum wave features a smooth surface and leads to both the greatest wave height and major inclination [7]. The maximum wave only forms under specific conditions and is highly sensitive to any variations in these conditions. For instance, a 5 % reduction of the tailwater height reduces the total wave height by 50 % [5]. Previous studies investigated the physical mechanisms for the wave formation process [6,5,8]. However, given the restricting simplifications made in the different experimental set-ups, the results of these studies are not transferable to the Neckar River.

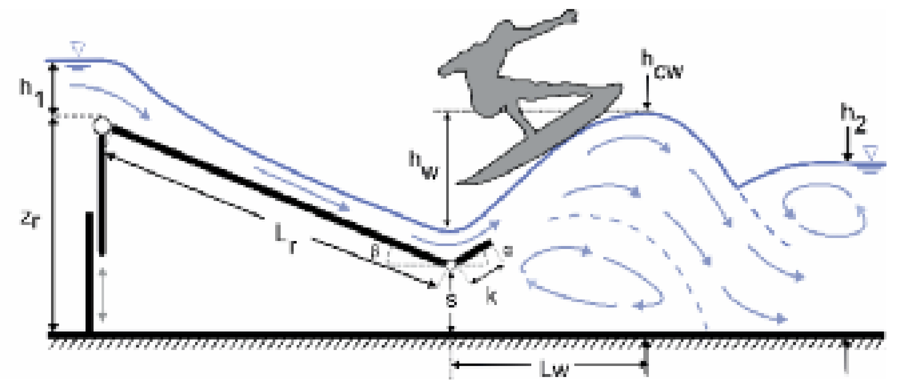
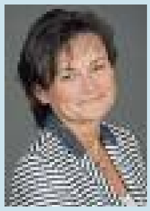


Figure 3. Schematic sketch of working principle and experimental set-up

Dominik K. Puckert graduated in Aerospace Engineering and currently works as a Ph.D. student at the Institute of Aerodynamics and Gas Dynamics, University of Stuttgart. His research subject is on experimental boundary layer instabilities and his passion for surfing made him member of the management board of Neckarwelle e.V.

Benedikt Mester, as part of his master thesis, conducts the physical 'Neckarwelle' experiments at the University of Stuttgart. His research interest focuses on PIV, CFD and hydromorphological processes.

Markus Noack is the head of the Hydraulic Laboratory at the Institute for Modelling Hydraulic and Environmental System, University of Stuttgart. He joined the IAHR committee for Experimental Methods and Instrumentation in 2017 and his research is focused on experimental investigation of hydraulic and sedimentary processes.



Silke Wieprecht is Professor and head of the department Hydraulic Engineering and Water Resources Management at the Institute for Modelling Hydraulic and Environmental System, University of Stuttgart. Currently, she is Vice President (Europe) of IAHR and responsible for Innovation and Professional Development (IPD) activities within the association.
Her research interests lie in exploring Environmental Systems, Hydromorphology as well as Monitoring, Measuring and Modelling.

Physical Experiments

A scaled model of the planned design was constructed in a laboratory flume at the Hydraulic Laboratory of the Institute for Modelling Hydraulic and Environmental Systems, University of Stuttgart, Germany.
A novel aspect of this work is the combination of all relevant hydraulic and geometrical

parameters in one physical experiment. The upstream boundary conditions are determined by the power plant operation as well as by the natural fluctuations of the flow rate whereas the downstream boundary conditions are determined by the water level of the Neckar River. Investigations into the influence of the different parameters will lead to a deeper understanding of the wave formation mechanisms, which is vital to adapt the prospective wave to naturally fluctuating boundary conditions.
The experimental setup comprises a height-adjustable ramp to impound water in order to gain potential energy and to accelerate the flow towards the wave. At the end of the ramp, a deflector is attached for the fine-tuning of the wave s face. Both the deflector and the ramp are variable in length and angle to examine whether the step height beneath the deflector or the inclination of the ramp is more important for the wave formation. In addition, other aspects of the design, such as the influence of the ramp's length, have not been addressed in the literature to the authors' knowledge. It is noted that different studies on surfing facilities do not show good agreement on whether a deflector only balances the tailwater fluctuations, or if it can actually increase the wave height [5, 8].

Numerical simulations

The experimental work is supported by numerical simulations performed at the Institute of Aerodynamics and Gas Dynamics at the University of Stuttgart. The open-source code OpenFOAM is used to simulate the wave using the finite volume method. Two approaches are used to simulate the interfaces of air and water, namely the volume-of-fluids method and the isoAdvector method. The simulations are first verified with a simple geometry against the experimental data and will then be extended to more complex geometries at a later stage of the project.

Future work

The results of the experimental and numerical studies will provide information for the conceptual design of a hydraulic structure that produces surfing waves for the varying boundary conditions at the Neckar River. Many additional investigations of non-technical aspects of the planned Neckarwelle are currently ongoing such as looking at water quality, ecological aspects, safety, legal issues and financing. This work is performed in close cooperation with the City of Stuttgart, Neckar River authorities, the hydropower company and residents. The social impact of the surfing wave facility on Stuttgart will be immense. The goal of the team of surfers and scientists working on this project is to bring together all groups of different ages and social backgrounds interested in this exciting sport.

Acknowledgements

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Pavel Novak (1918-2018)

Professor Pavel (Paul) Novak passed away on the 24th of February 2018 at the age of 99. He was born on the 7th of September 1918 in Stribro, now located in the Czech Republic. He lost family to the Holocaust and first came to England during WW2, studying engineering at the University of London, and making a contribution to the war effort by interrogating German POWs and as a member of the Home Guard. He met his future wife Elizabeth (Eli) in 1943 while staying in Nottingham. After the war he returned to Czechoslovakia, was from 1950 to 1955 Deputy Director of the Water Research Institute in Prague and later Director of the Institute of Hydrodynamics, the Czechoslovak Academy of Sciences. In 1968, when the Soviet army invaded Czechoslovakia, he returned to Britain where he was offered a position at Newcastle University.

Prof. Novak was an internationally leading hydraulic engineer, and wrote several noteworthy books on the subject. He was Professor of Civil and Hydraulic Engineering in the Department of Civil Engineering from 1970-1983 and was Head of Department 1981-83. Pavel retired then and was accorded the title of Emeritus Professor. By then, the Water Resources Group was the largest such postgraduate group in the UK. His contribution to Newcastle was immense and he continued until recent times as an author and mentor. He held the University and city in his greatest affection as a place where he found freedom from the difficulties in central Europe in his earlier life. This affection is reciprocated.

Prof. Novak was the first official Editor of the Journal of Hydraulic Research (JHR) from 1983, following Johannes T. Thijsse (1893-1984), who had done this job as IAHR Executive Director from JHR foundation in 1963. Pavel has taken this position for 8 years until 1991, from when JHR Editors serve for 5 years. Pavel must be credited for having made JHR an internationally accepted journal, one of the few then published in Europe. In parallel, Pavel was a successful book author. Of note is his book Models in hydraulic engineering (1981) written jointly with Jaroslav Cabelka (1906-1989), his Hydraulic Structures (2001) and his Hydraulic Modelling (2010). In addition, he was the editor of the book series Developments in Hydraulic Engineering. He also authored more than 100 journal and congress papers. Pavel Novak was an Honorary IAHR Member and awarded the ASCE Hydraulic Structures Medal, among others. He was awarded in 2008 the highest honorary medal 'De Scientia et Humanitate optime Meritis' of the Academy of Sciences of the Czech Republic.

In his retirement, Paul painted landscapes with great enthusiasm and continued to write text books. He travelled widely and enjoyed many years of activity, only giving up skiing in his 70s.

Following the death of Eli after 70 years of marriage, he spent his last years in The Philip Cussins House in Gosforth he communicating from there with family, friends and colleagues often via email. Those, who were present at the 2017 ICE Seniors Annual Lunch will recall how he spoke, still with clarity and strength.

Pavel is survived by his son Michal, daughter Zuzana, and over 50 grandchildren and great grandchildren. He will be greatly missed by all who knew him.

Eric Valentine and Willi H. Hager

DESIGN OF AN ARTIFICIAL SURFING REEF AT SOMO-LOREDO BEACH

BY JARED ORTIZ-ANGULO CANTOS

Surfing has been increasing in popularity over the last few decades. In order to have good conditions for surfing, several factors must simultaneously coincide. These include swell waves, off-shore winds and the optimum bathymetric configuration. Beach profiles and reefs that yield suitable waves for surfing are difficult to find in nature. This drives coastal engineers to construct reef like artificial submerged structures to improve the interaction between the wave and the sea bed and enhance the quality of the waves for surfing. The design of these reefs is inspired by natural reefs with perfect surfing waves. The aim of this research is to provide a novel numerical approach for the design of submerged structures that improve surfing conditions and to study the economic viability of an artificial surfing reef in Somo-Loredo, northern Spain.

The Cantabrian Coast in northern Spain, has many locations with good potential for surfing. Ribamontán al Mar is one such location. It is a coastal town that has undertaken some interesting initiatives in the area of surfing resource management. One of these is a project to explore the possibility of constructing an artificial surfing reef to improve conditions in the area.

Ribamontán al Mar is demonstrating how a local economy can be rapidly improved by the growth of tourism. Surf tourism attracts over 15,000 visitors a year and generates 4.2 million euros for the local economy as well as it provides 720 jobs. The local area has been transformed with the establishment of 22 hotels, 20 rural accommodations, 10 tourist apartments, 4 campsites, 32 restaurants, 34 pubs, 8 surf shops, 9 surf houses and 2 shaping workshops. All this development has attracted interest from overseas in the business model with visitors coming from Chile, Morocco and Guinea over the past two years. The area, including Somo-Loredo, Langre and Galizano beaches, has been recognized as a "Natural Surf Reserve" due to its attempts to promote surf tourism[1].

The construction of a reef-type submerged structure at the beach of Somo-Loredo could improve the surf quality in the area, increase tourist appeal while at the same time provide protection to the dune system behind.

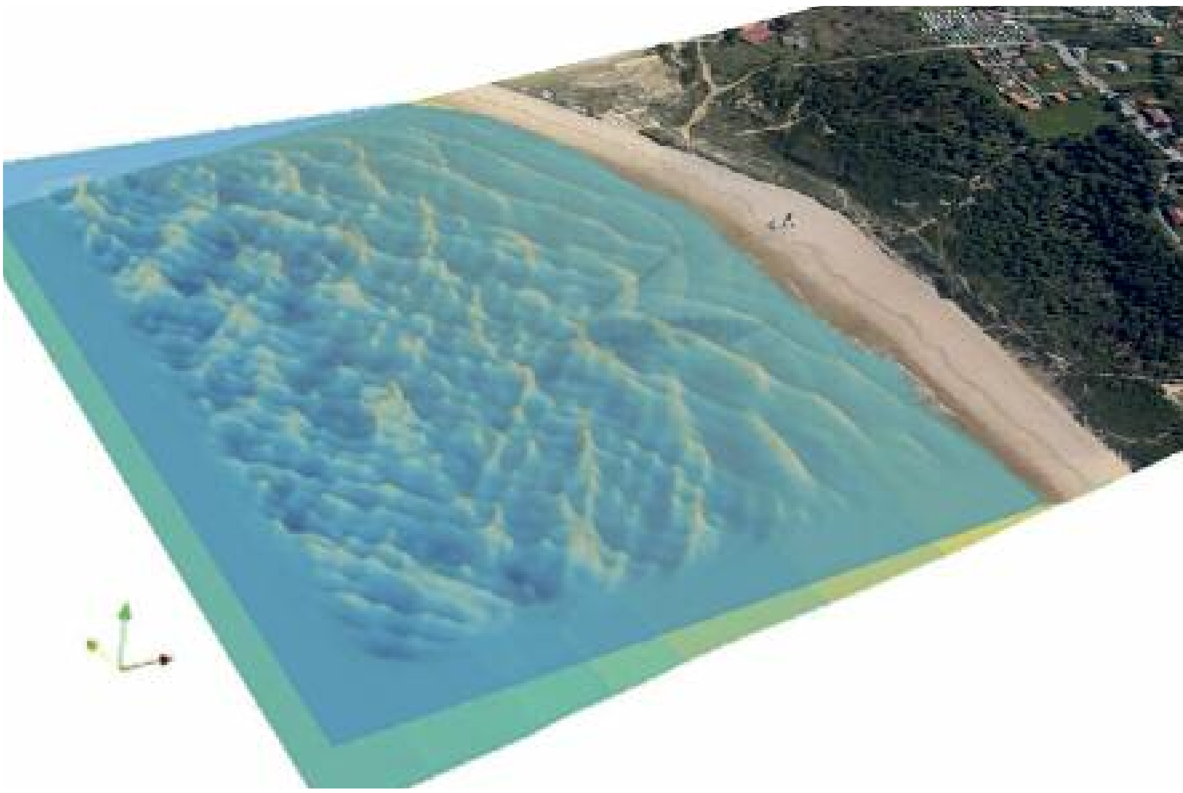

Figure 1. Graphic representation of the results obtained from the Somo-Loredo Beach simulations carried out with the numerical model IH-Bouss

Jared Ortiz-Angulo Cantos has a MSc in Coastal Management Sciences and Technologies from the University of Cantabria and a M.Sc. in Civil Engineering from the University of Granada. Since 2017 he has been working at MCVALNERA as consultant, specializing in computational fluid dynamics applied to coastal hydrodynamics processes. His final master's project, "Design of an artificial surfing reef at Somo-Loredo beach" , was awarded the III Edition of IIAMA award given to the best Academic National Work in the field of Water Engineering. He also regularly collaborates with the prestigious Spanish surfing magazine "Surfer Rule".

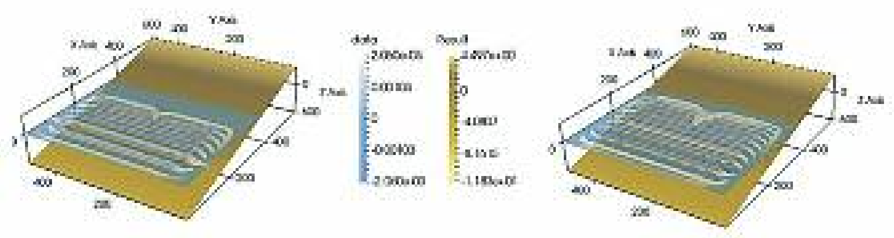

Figure 2. IH-Bouss 3D representation of 2 different sea states iteracting wiith a V-shape artificial reef

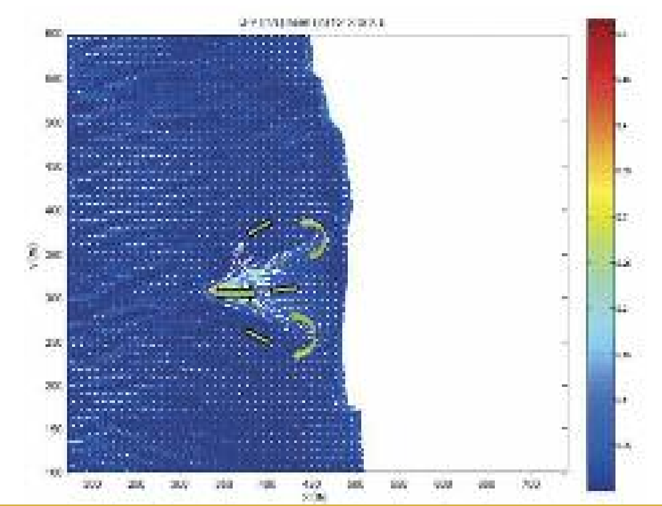

Figure 3. Graphic representation of the currents results obtained from the simulations carried out with the numerical model IH-Bouss

A study was undertaken for the technical design and the assessment of the economic feasibility of an artificial surfing reef to be located at Somo-Loredo beach. The study included the following steps.

Study of wave-reef interaction

In this first phase, the study determined the correct geometry of the reef bathymetry for surfing from the parameters involved in the wave-reef interaction process. One of the starting points was the 2012 study of Mendonça et al [2], wherein two types of artificial reefs were designed with the use of a numerical tool and were analysed for different wave conditions. The study of Mendonça et al was based on the results of the 2009 work of Voorde et al[3] and allowed the development of basic design guidelines for a V-shaped artificial reef. In this study a Boussinesq equation-based numerical model was used (IH-Bouss). This model can handle wave propagation and interaction (including wave breaking) with the submerged V-shape artificial under any real wave forcing (random waves). The use of this numerical tool made it possible to determine the geometry, size, orientation, freeboard, etc. of the reef based on the wave climate statistics in the study zone.

The results for the different simulations include: wave height maps at some relevant cross sections, surf similarity parameters for different incident wave spectra, wave breaking induced currents and wave breaking line plots. Most of the results obtained can be easily used to identify surfing suitable areas.

Optimization of the reef design

After numerically analyzing the wave-reef interaction with different V-shaped structures, taking into account the whole wave climate, a tailored fit structure was designed for Somo-Loredo beach. The final design was optimized following the hierarchy of surfing levels proposed by Espejo Hermosa[4], as follows:

Level 3 – Optimum conditions:
1.2 m $\leq$ Hs ≤ 2 m; 12 s $\leq$ Tp < 16 s;
Level 2 – Appropriate conditions:
0.5 m $\leq$ Hs < 1.2 m; 8 s $\leq$ Tp < 12 s;
Level 1 – Adequate conditions:
0.3 m $\leq$ Hs < 0.5 m; 6 s $\leq$ Tp < 8 s;
Level 0 – Unsurfable conditions:
Rest of conditions.
where Hs is the significant wave height, and Tp is the peak wave period.

In the optimization procedure, two basic studies were performed. The first one dealt with the variation of the average energy flux at four locations on the structure. From these results, it was noted that the variation in energy flux across the structure was minimal and it would not have any significant effect on the morphodynamics of the beach. The second analysis was a sensitivity study of the percentage variation in the surfing levels[4] after the construction of the artificial reef. The most relevant result was that the percentage of occurrence of level 2 (Appropriate conditions) was tripled.

Surfing-reef construction

The proposed construction procedure is innovative, environmentally friendly and economically feasible. It is proposed to use part of the sand dredged annually at the Santander Bay's channel to create the V-shape structure. It would be pre-designed for suitable surfing conditions. In order to preserve the reef shape, it would be covered with a thin polyurethane-sand mixed layer (0.1 m).

The cost of the project estimated (without considering the dredging cost) to be about 906,000.00 €, (based on a unit cost of 23,9 €/m³ of artificial reef).

Acknowledgements

The research project reported in this article was completed under the supervision of Prof. Javier L. Lara and Prof. Gabriel Díaz Hernández (both from The Environmental Hydraulics Institute "IH Cantabria" of the University of Cantabria).

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UNAUTHORIZED EXTREME ACTIVITIES AND PUBLIC SAFETY AT SPILLWAYS

BY STEVEN L. BARFUSS & BRIAN M. CROOKSTON

Pioneering research by the late Dr. Bruce Tschantz indicates that there are about nine times more deaths at dams than deaths caused by dam failures[1]. Many of the deaths that occur at dams are a result of recreational activities. Although fishing, boating, and swimming may be considered normal and common activities at many dams, the dam's spillway has become a destination for many thrill seekers who are climbing, jumping, diving, wakeboarding, surfing, snowmobiling, sledding, skating, and biking in these hydraulic structures[2]. A portion of these unauthorized and hazardous activities are self-recorded and posted to social media.

According to the Canadian Dam Association (CDA), many drownings occur because the public is generally unaware of the dangers associated with spillways and dam operations[3]. However, there are also numerous instances where victims ignored security and safety measures (e.g. signage, fencing, and safety booms) in order to recreate in spillways. For some, trespassing and the efforts required to access spillways are part of the thrill they seek.

Figure 1. Individuals engaged in unauthorized and hazardous recreational activities in spillways; biking (top) and spillway boogie boarding (bottom)

One recent example occurred on Sept. 11, 2017 when the first successful swim was made across the turbine intakes at Hoover Dam[4]. These intakes first began operation in March 1937 and no previous swimmer had escaped the strong currents created by the operating turbines. Gratefully, officials noted that during this man's 30-min treacherous swim, only one of ten turbines was operating. Even then, the man reported great difficulty escaping the current from the single turbine. Although law enforcement was glad that he survived, the man was given a hefty penalty and concern exists that 'copycats' may attempt this same suicidal activity.

There is clear evidence that many daredevils are highly motivated by the excitement of extreme activities and the attention and potential income that can come by posting photos and videos to social media. Many videos posted online of extreme unauthorized activities at dams have gone viral. This of course only perpetuates the problem, because many viewers want to experience the same thrills that are presented in each posting but may not realize they are risking severe injury or death.

On the FEMA website in which "Public Safety Around Dams" is discussed[5], it reads: *"The nature of public interaction with dams is changing and guidance is needed to increase public safety around dams. Public interaction with dams is increasing for several reasons, including lack of awareness of hazards, public interest in "extreme" sports, recreational vehicles improving access, a perceived right of public access to sites, and the remote operation of dams. Dam owners need to consider how the public interacts with and around their dam, and establish appro-*

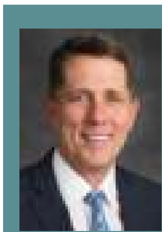
Figure 2. Drunk man receives hefty penalty for swim across Hoover Dam intakes

priate procedures, restrictions, and safety measures." The site also has several references that discuss the topic of this paper and the associated recommendations for improving public safety around dams.

The authors believe that 1) Effective warning methods, 2) educating the public and 3) the threat of legal action are three methods that are most effective for mitigating risk to the public as they recreate near hydraulic structures. It is apparent that when dam owners do not have these safety measures in place to protect and/or prevent the public from hazardous structures or hydraulic conditions (like the reverse current that often occurs at low-head dams), injury and death are much more prevalent. Although, these methods will not stop all individuals from illegally accessing a dam for recreational purposes, they will however provide sufficient warning and protection to most.

Visual and audible warnings

The Canadian Dam Association has prepared specific instructions for improving the safety at dams in the bulletin entitled, "Guidelines for Public Safety around Dams (2011)". The authors suggest that dam owners and operators implement signage, booms and buoys and audible and visual signals to help protect the general public from personal injury and possible death. Dam owners and those concerned with public safety at dams have observed that adequate warnings of the dangers and penalties resulting from illegal access are effective deterrents. Other highly effective deterrents are security cameras or periodic patrols of restricted areas.



Steven L. Barfuss, PE is a Research Professor of Civil and Environmental Engineering at Utah State University in Logan, Utah, USA and has been employed at the Utah Water Research Laboratory at USU since 1987. His research includes the physical and numerical modeling of dams, spillways, and energy dissipation structures. He has served as the United States Society of Dams, spillway subcommittee chair since 2011.

Brian M. Crookston, PhD, PE is an Assistant Professor at Utah State University and also serves on the IAHR Hydraulic Structures leadership team. His research and consulting interests are focused on water conveyance and dam safety, including the design of hydraulic structures, nonlinear spillways, flow acoustics, energy dissipators, scour, fish passage, dam breaches and flooding, and physical and numerical modeling of hydraulic structures. Previously, Brian was a Senior Engineer at Schnabel Engineering.

Education

Education is perhaps the most effective means for reducing injuries and deaths at spillways. Many States in the U.S. have implemented educational programs to help people understand the inherent risks associated with dams. Like driving a car and the associated driver's training, those that recreate on and near dams will, through awareness and improved judgement, be safer when they are taught the dangers that are inherent at dams and spillways. Because most recreational activity injuries and deaths occur to individuals ages 18-30, it is expected that providing education to children and teenagers will be most effective.

Legal Action

Although social media is used to advertise many of these hazardous activities, it can also be helpful in recognizing and discouraging those who may view the post and want to copy-cat the stunt themselves. Authorities in North America who find social media posts of unauthorized activities at their dam have improved public safety by strictly warning the individual(s) who originally posted the illegal activity that, if others mimic or copy them, they will be held legally responsible for any resulting injuries or deaths that might occur at their facility. This approach has had great success in removing social media posts. Signs that explicitly warn potential trespassers of specific hazards and penalties, such as how one might drown, hefty fines, and jail time also are helpful in discouraging illegal recreationalists. ■

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THE ENGINEERING OF WATER FEATURES

BY STEPHANE LLORCA

As cities are growing and transforming all over the world, the ambience of public areas is becoming important from the perspective of planners and residents alike. Water features and fountains make our cities more enjoyable. They introduce a sense of nature into the urban environment, providing people with a stronger connection to climate, natural cycles and personal fundamental needs. They enhance existing settings (such as parks, city squares) for social interaction, acting as a focal point that brings people into contact with one another and that sparks human connections, which are becoming increasingly rare in today's urban environments. Water feature designers develop new concepts and incorporate cutting edge technology to provide unique delights for citizens in the urban environment.

Water lies at the heart of society. When urbanization started on the banks of the Tigris-Euphrates river system some 3.300 years BC, it was soon clear that the control of water was a powerful tool that could accelerate development and was a strong symbol of civilization. Since then, our ability to control water has been constantly evolving and expanding.

Water feature designers utilise the fundamentals of fluid dynamics, set by early hydraulic engineers such as Darcy, Bazin and Manning, whilst adding some spice to these empirical calculations by way of the artist's poetic touch and the architectural understanding of spatial experience. Water feature design is an unusual field as it lies between hydraulic engineering, architecture and art. Each project is a

Figure 1. Le miroir d'eau of Bordeaux. Photograph Haut relief.

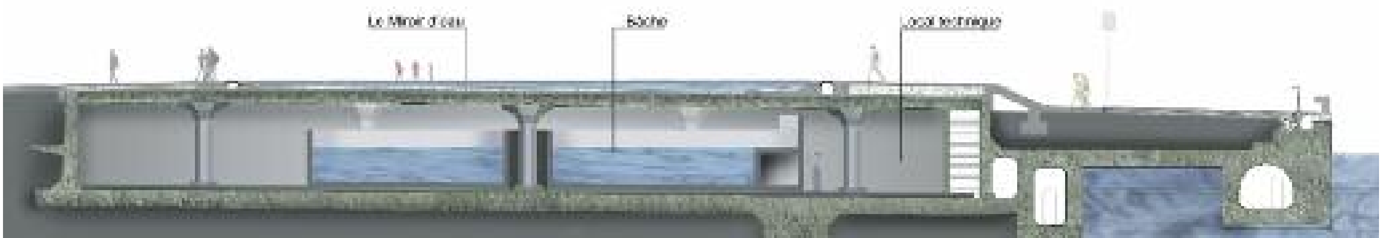

Figure 2. Le miroir d'eau of Bordeaux. Transversal section. JML


Figure 3. BHP Billiton water park, Perth . ARM/TCL/JML


Stéphane Llorca is the managing Director of JML Water Feature Design.
JML is one of the world's most dynamic water feature design companies, lauded for innovation, artistry and technical excellence.
Stéphane and his team are collaborating with the most prominent architects worldwide, always pushing boundaries and creating bespoke experiences.

comprehensive integration of ideas, design and techniques that may require complex technologies and computerized programing to create a water choreography, or it may take a more minimal approach and simply rely on the natural luminous and reflective characteristics of water.

Water feature design and installation in an urban environment faces a number of challenges:

- **Resilience:** A city environment can sometimes be harsh, and water features must be designed to weather these urban conditions, such as high levels of dirt, pollution and vandalism. For example, polluted water can damage even the most resistant materials by erosion or corrosion. Designers are continuously compelled to innovate, anticipate new problems and develop robust engineering processes.
- **Safety:** The system must be safe for users and operational staff. Children are naturally fascinated with water and tend to play near such systems and, from time to time, sample some of the water for drinking. For this reason, the majority of fountains are filled with potable water, whilst water treatment and filtration systems are also incorporated in order to constantly maintain a good water balance. The maintenance and cleaning of these features is crucial for long term operation. Special spaces must be designed to accommodate all the necessary mechanical & electrical systems and allow for regular cleaning and replacement.


Figure 4. Return pipes. Photograph JML

- **Sustainability:** Climate change is indisputably impacting our societies.
  Methods and strategies for saving water must be implemented in fountain systems and, although the water consumption of fountains when compared to a city's overall consumption is negligible, their visibility means they have a strong impact on the public perception of a city's water consumption and conservation.

As our cities and societies are constantly changing over time, so are fountains. A new generation of fountain has emerged over the last two decades; today's fountains are more interactive than the ornamental fountains of the past and the public is invited to engage, play and refresh. New dry-deck fountains mean that visible pools are no longer necessary, with the water jets surging directly out of the ground and the water gathered and recirculated in a closed circuit. The water is stored, when not in use, in an underground or hidden reservoir. This type of system offers greater flexibility for the use of public areas, or plazas as the space becomes available for other uses when the fountain is off.

The latest trend is now the so-called "miroir d'eau". Completed in 2006, the extraordinary water feature at Place de la Bourse in Bordeaux, France became a worldwide reference. The concept consists of reproducing a natural flood and was inspired by the San Marco "aqua alta" condition in Venice. In less than 5 minutes, the 3,000 m^2 of the Plaza is covered with a thin layer of water. This radically changes the perception and use of the Plaza, creating beautiful new perspectives by reflecting the surrounding classical architecture.
Soon after, the water disappears and is succeeded by an ephemeral cloud of fine mist that forms in the middle of the square, morphing and shifting in the wind, radically shifting the ambience of the square (Figure 1).
Water is stored in a large underground reservoir (Figure 2). It is brought to the surface using pumps to fill hundred small channels laid out underneath the flagstone before overflowing through the joints to spread over the entire surface of the plaza. Water quality is constantly monitored and the system includes an automatic water treatment and filtration system.

The project of Bordeaux has been a great success and is now being reproduced at different scales at various locations around the world. For example, in Perth, Australia, the recent transformation of Elisabeth Quays included a similar feature which adds more complexity as water depths can vary from 0 to 40 mm (Figure 3). This creates the possibility for a large variety of sequences and experiences, whilst a series of return pipes (Figure 4) with motorized valves can drain the feature in a matter of seconds. ■

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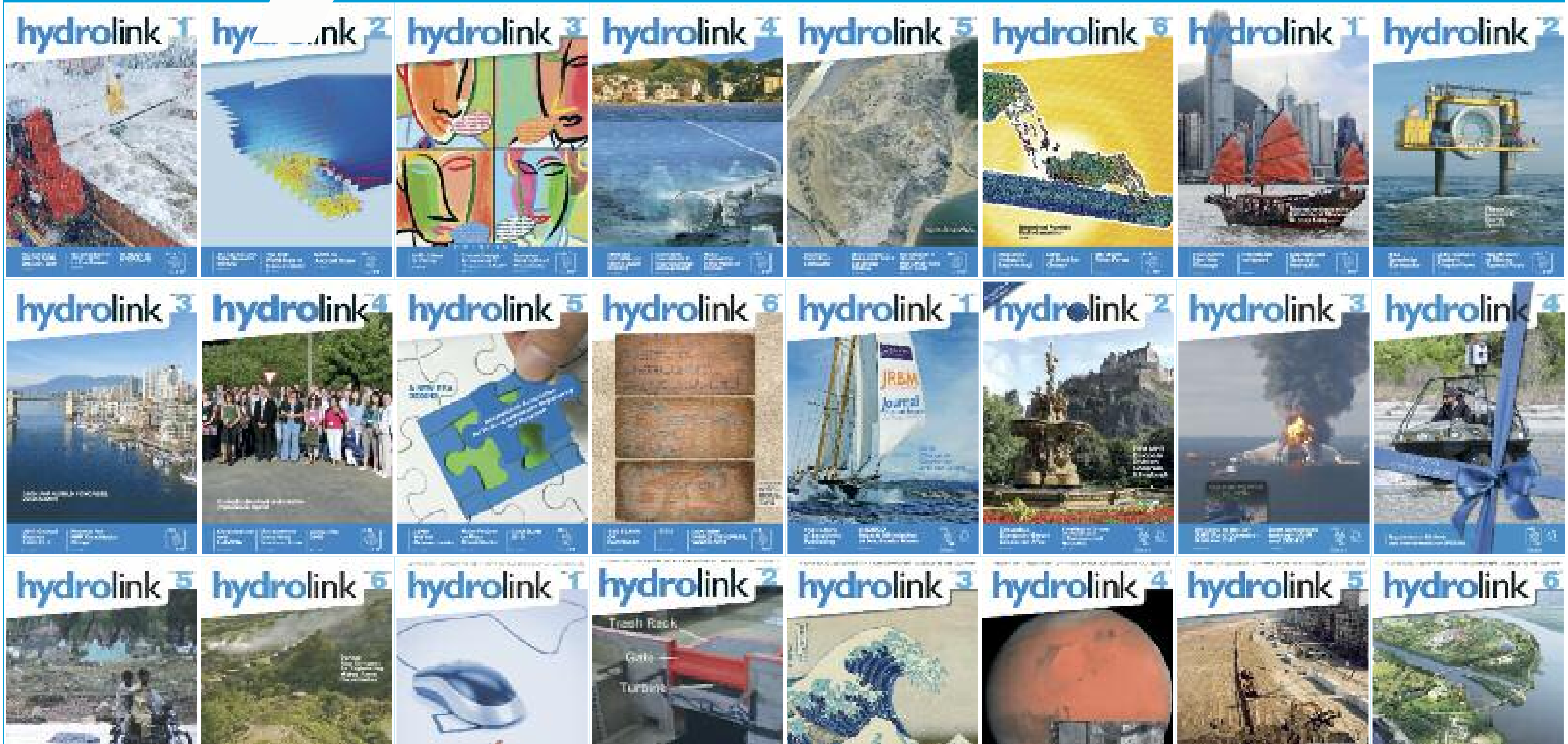


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IRRIGATION SYSTEM PERFORMANCE IN A LIVING WALL

BY DANIEL ALBERTO SEGOVIA-CARDOZO, LEONOR RODRIGUEZ-SINOBAS & SERGIO ZUBELZU

Population growth and the increase in the migration from rural to urban areas, contributes to higher air temperature and different forms of pollution in many cities. To counter these effects and improve the environmental conditions, an increasing number of living roofs and walls has been developed in the last few decades. Living walls require the application of water by an adequate irrigation system adjusted to their individual characteristics.

This article describes the performance of a drip irrigation system that provides uniform water distribution to the living wall on the East façade of the itd-UPM building (Centro de Innovación en Tecnología para el Desarrollo Humano) located in Madrid. (fig. 1).

The living wall consists of 168 plastic pots, each with a volume of 1330 cm3, arranged in 14 columns and 12 rows, covering a total area of 4.44 m^2. The living wall is a mixture of seven plant species distributed randomly. Each of these plants has different irrigation requirements.

The water supply is delivered by the Madrid municipality. Water is carried to the irrigation inlet unit by a polyethylene pipe 21.2 m long, with 14 mm internal diameter. The system includes regulation (0.1MPa, nominal pressure) and automation elements including; flowmeters, electrovalves, filters and pressure regulators.

Figure 2 shows the irrigation unit. It is comprised of a submain, laid downwards the living wall, which fits 12 laterals, laid horizontally over the plant pots. All pipes are made of polyethylene with internal diameter of 14 mm. 14 emitters, spaced every 16 cm, with one emitter per plant pot, are punched in the lateral. A total of 168 emitters irrigate the entire living wall.

Figure 1. Living wall. Photograph: Daniel Segovia-Cardozo

The Living wall emitters (PCJ CNL, Netafim) are non-leakage and pressure compensating, with 2 L/h nominal discharge (Fig. 3). The operating pressure range is 0.07 to 0.4 MPa and the closing pressure 0.012 MPa. The variation of discharge coefficient, as provided by the manufacturer is 0.03.

The head losses in the supply pipe are small (hf = 0.0054 MPa), and the pressure head at the inlet of the irrigation system is 0.0946 MPa. This corresponds to the highest elevation in the system and not to the farther location from the inlet, because of the height variation in the living wall. The submain head losses are also negligible, at 0.00008 MPa, but the pressure head difference between the submain extremes is 0.0194 MPa, corresponding to the living wall height difference, which increases the internal pressure. Thus, the emitters at the last lateral worked above the pressure head at the inlet of the irrigation system with 0.11MPa and, probably, these did not properly closed, once the irrigation stops, increasing leakage, caused by the water pillar pressure within the pipe. As a result, it would be advisable to use emitters with adequate closing pressure and avoid leakage when the system stops operating.

Figure 3. Emitter type: external view (on the left) and internal view (on the right). Photograph: Daniel Segovia-Cardozo

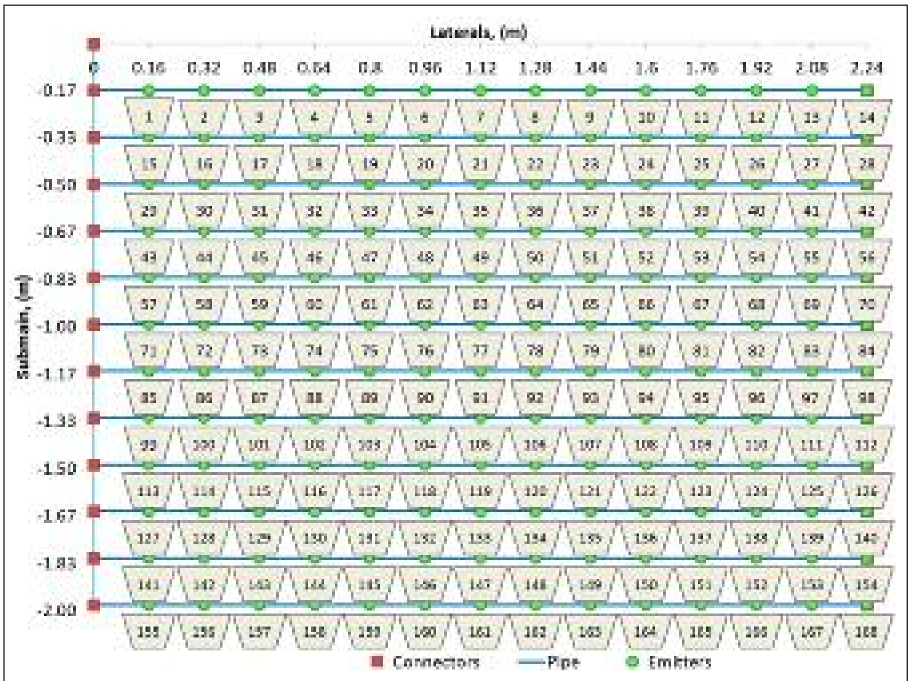
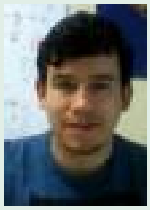
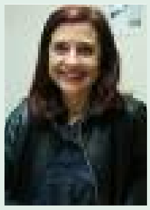


Figure 2. Scheme of the living wall irrigation unit: sub main line, laterals and emitters



Daniel Segovia- Cardozo is member of the Research Group "Hydraulics for Irrigation" in the UPM (Universidad Politécnica de Madrid). Recently, in 2018 won the urban nature award for researchers from FORO AGRARIO.



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Sergio Zubelzu Minguez is assistant professor at the Universidad Politécnica de Madrid. He is member of the Research Group "Hydraulics for Irrigation"

Figure 4 (a) presents the emitter discharge curve. It shows that the emitters behave in a pressure compensating manner above h = 0.07 MPa. However, their discharge increases drastically with pressure below this value. The emitter's discharge is also affected by the water temperature, increasing within its compensation range, and decreasing below it (Fig. 4 b and c). This can be explained by the fact that the dilatation of emitter's materials caused by the temperature is more significant than the water viscosity effect.

The percentage of open emitters varies within the range (0.012 ≤ h ≤ 0.04 MPa) (Fig. 4 d) which shows that some emitters close early than others.

The variation of the discharge coefficient (CV) of emitters is small, 0.039 although the temperature is shown to have the highest impact in CV. If the emitters operate at a very low pressure head, the CV increases drastically. This is caused by proportion of open and closed emitters, principally.

The water distribution uniformity of the emitters (estimated by the statistical uniformity coefficient which was estimated to be 0.96) is very good as long as the operation pressure is within the emitter compensating range.

It must be noted that the height difference in the living wall could affect the performance of the irrigation system, and thus the water distribution among the plant pots.

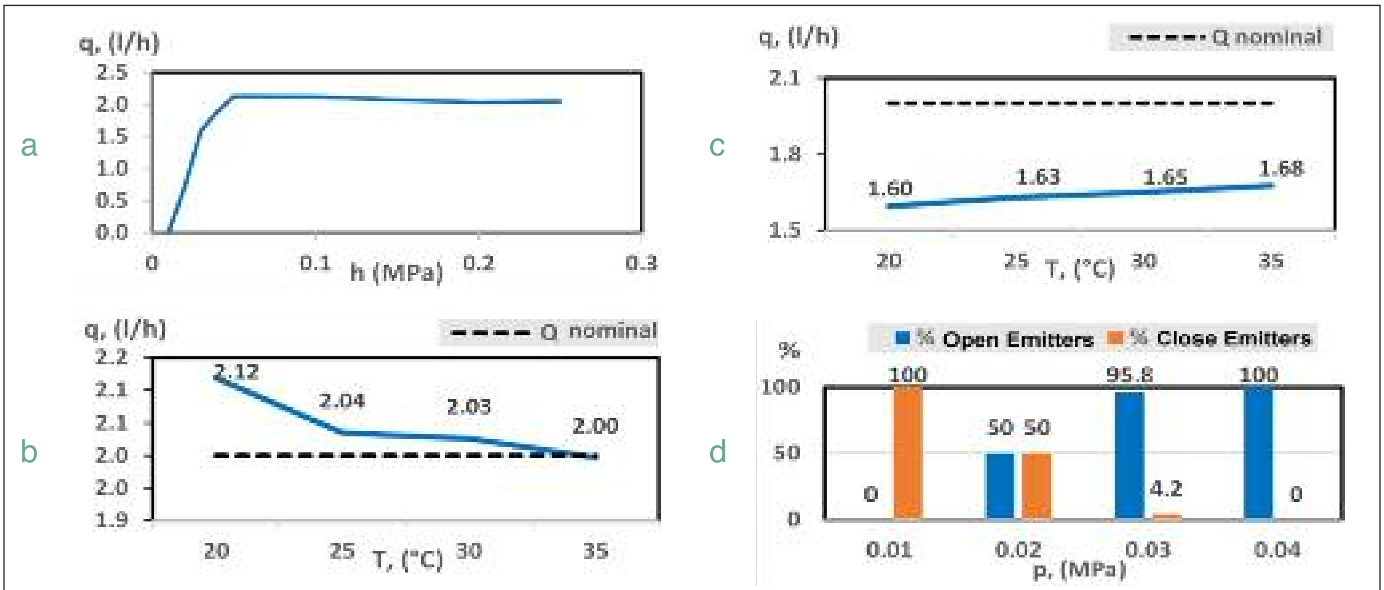


Figure 4. Emitter discharge characterization: discharge curve (a), temperature (T) effect within the pressure compensating range (b) and below the compensating range (c) Open-close emitters depending (d)

FORESIGHT STUDY: FUTURE DEVELOPMENTS IN PHYSICAL MODELLING OF CLIMATE CHANGE IMPACTS

BY ANA MENDONÇA, STUART MCLELLAND, KARL-ULRICH EVERS, MORITZ THOM & PAULO ROSA SANTOS

The HYDRALAB+ Project is an advanced network of European research organisations that focus on physical modelling of environmental hydraulics. The aim is to develop and improve the experimental facilities for the investigation of expected climate change impacts to ensure that future management and adaptation measures are effective. An important aspect of this work is to identify new or alternative experimental methods and resources to better support future work in modelling climate change impacts and adaptation strategies.

The estimated rise of mean sea water level and increased occurrence of storms in the coming decades prompts our societies to rethink exploitation of the coastal, riverine and polar regions worldwide. The coastal and riparian zones are often heavily urbanized and are therefore very important for industrial development, commerce and tourism. Facilities, infrastructure and protective structures, along the margins of water bodies, have been constructed based on design life expectations, which are typically derived from extrapolations of historical design parameters, but do not necessarily account for inevitable climate change impacts in the design process.

Conflict is almost inevitable with the continued development of areas where there is interaction with coastal, fluvial, and ice processes. Development and exploitation of resources requires stability, whilst it is evident that natural processes are subject to constant change.

In this context, the Foresight Studies, a networking activity of HYDRALAB+ project [1], have been employed to identify and highlight areas of recent novel developments and to define the combined requirements for morphological, ecological and structural methods in experimental modelling to improve our understanding and response to climate change issues through adaptation in rivers, coastal and offshore regions such as that shown in Figure 1.

This work is focused on the variables and forcing to be represented in the experimental domain, the measuring equipment and technologies, as well as the experimental procedures, methodologies and facilities for analysing processes in dynamic coastal, fluvial and polar regions.

Figure 1. Climate change in coastal environments (Source: hydralab.eu)

Climate change impacts will alter many important boundary conditions (e.g. rise of mean sea water level, increased storm events – both in terms of intensity and frequency of occurrence, etc.). The related development of management approaches to adapt to these new boundary conditions brings new and significant challenges to experimental facilities worldwide, at different temporal and spatial scales across climate change related topics.

Current limitations for experimental modelling

Most experimental facilities have the capability to simulate typical forcing to represent the system being modelled (e.g. waves, unidirectional or bidirectional currents and ice) however there are limitations. In many cases only a single forcing can be represented or there are compromises in the simultaneous action of multiple forcing (e.g. wave paddles interact with flow currents). Technical limitations may also be an issue, for example, traditional wave basins and flumes have conservative limits in terms of wave steepness compared to wind-generated waves in the natural environment. On the other hand, discharge hydrographs in fluvial models are often represented by step changes rather than being continuously variable. In addition, the modelling of climate change scenarios requires changes in forcing to be more intense, frequent and unsteady (e.g. seasonal or inter-annual variability, in conjunction with the slowly varying system change). Climate change effects are also expected to lead to more frequent storm events with steeper waves (i.e., with a higher wave height to length ratio) and potentially more frequent, intense and/or localised rainfall events driving flood events.

Since there are significant uncertainties in predicting the effects of climate change in the variables driving the design of coastal and hydraulic structures (i.e., establishing the sea level rise or predicting extreme flood events), the use of multiple scenarios to predict possible future realities (in the medium- to long-term) is of paramount importance. However, modelling multiple scenarios is time-consuming and therefore expensive. Thus, the key question is, how to correctly select representative conditions to be considered in any test programme. This requires the merger of probabilistic approaches like joint probability analysis with experimental programme design to improve the operational effectiveness of physical modelling studies.
In addition, the relevance of reproducing sequences of extreme events over the life span of a structure, including their cumulative effects, needs to be highlighted [2; 3; 4]. Cumulative effects due to storm sequences may, for example,

produce progressive failures in coastal defence structures due to armour instability and related overtopping of structures. Therefore, in this example, an appropriate description of storm evolution is critical for simulating damage progression and its impact on wave overtopping. Similarly, the morphological evolution of natural features like beaches and river channels depends not only on the erosive impacts of storm events themselves, but also on the antecedent conditions which dictate the state of the system prior to a storm event. Hence, the modelling of extreme events depends on the chronology and sequencing of both energetic and quiescent events.

Global warming has also significantly reduced sea ice extent in the Arctic and, with ice cover retreating, Arctic sea ice is surrounded by more open ocean than land. The marginal ice zone (MIZ) is the transitional area between the open ocean and pack ice cover. It consists of individual ice floes of varying size often formed by ocean waves penetrating a solid ice field. Both winter navigation and offshore structures may be impacted by MIZ conditions for at least part of the ice season. However, there is insufficient understanding of the air-ice-ocean system to operate effectively in this region. In particular, the increased area of open water in the Arctic has amplified wave intensity. Hence, wave propagation through dynamically changing ice cover in the MIZ has become an important topic for maritime operations in the Arctic [5]. Therefore, predicting the wave climate and its effect on structures in the MIZ is of practical importance since waves affect the ice breakage, while the ice contributes to the attenuation and dissipation of waves [6].

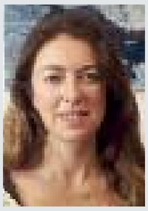
Despite its importance, limited data are available for wave propagation in the MIZ. Field measurements [7] and remote sensing [8] data have been gathered and laboratory experiments have been conducted [9]. However, these studies have only scratched the surface of the complex wave-ice interaction problem and a systematic study is urgently required to develop a better understanding for Arctic engineering in the MIZ.

For many facilities it is often difficult to work with living organisms because the local environmental conditions such as light, water quality, temperature, etc. cannot be controlled or maintained to ensure survival for the duration of the experiment. Although there are some facilities that can support the growth of organisms, such as mussels or eelgrass, they are often not equipped to create the full range of waves or flows over representative length and time scales in relation to the size and growth or reproduction cycles of the organisms. In addition, the time required for such experimentation would make such work prohibitively expensive.

Another serious problem is that plants require time to grow. Changes in the density and biomechanics occurring on seasonally (winter die-off) as well as on inter-annual scales result in experiments that are unrealistically long. To solve this issue, the use of surrogates has been investigated intensively in HYDRALAB research, but numerous issues still remain unresolved and organism response to climate change is only one of those. Furthermore, the inherent variability of organism response to the same environmental conditions requires numerous repetitions of experiments to satisfy statistical significance tests, which are necessary to distinguish random variability in organism response from the causal response due to changes in environmental variables.

To improve the understanding of fluvial processes, a better knowledge of the uncertainties in the required inputs (climate change model predictions) is needed. One approach to improving the representation of these uncertainties would be the development of probabilistic approaches (like those used for simulating coastal processes) to help reduce and characterise uncertainties. Improved methodologies are also required to better represent the unsteadiness and variability of flow processes.

Interdisciplinary collaboration is generally underdeveloped, and there is the need for a more integrated approach to experimentation. For example, in some fluvial/coastal environments, the study of climate change effects and adaptive measures might involve the unusual combinations of physical processes. For example, the modelling of soft cliffs, may require the reproduction of extreme rainfall events which necessitates the accurate modelling of rain intensity and its spatial distribution in time which in turn requires different scaling effects to be resolved (e.g. tension effect in water drops). In addition, integrated management approaches are likely to be adopted when addressing climate change impacts therefore fluvial and coastal systems cannot be considered (or modelled) in isolation and similarly the role of biota in the environment cannot be ignored. Therefore, it is expected that ecohydraulic modelling will become increasingly important.



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Paulo Rosa Santos is Professor in the Faculty of Engineering of the University of Porto, Portugal, and integrated member of CIIMAR – Interdisciplinary Centre of Marine and Environmental Research. Research field: integrated application of physical and numerical modelling in the study of offshore, port and coastal related issues. Areas of expertise: ocean renewable energies, costal and harbour structures, moored ship dynamics.

Foresight studies

The representation of climate change impacts in physical models still presents significant challenges. The HYDRALAB foresight studies aim to identify the requirements in terms of experimental facilities, equipment, methodologies, datasets and model/field experiments to make a step-change in modelling climate change impacts and the managed adaptation to climate changes, for coastal, ice, and fluvial processes.

In terms of experimental facilities, equipment, methodologies and datasets, the main needs are:

- Development of laboratories and simulators in the natural environment to enable unscaled experiments to investigate critical properties of the prototype that cannot be scaled (e.g. behaviour of animals such as burrowing);
- Improve landscape scale observation capability to better capture validation data and ensure that the entire system is properly represented in experimental models (e.g. remote sensing surveys such as LIDAR);
- Improve the operational range of existing laboratory equipment process interactions (e.g. wind, wave, current and tide);
- Improve experimental facilities and methodologies to better reproduce the (sometimes complex) characteristics of the natural environment (including its ecological components) with respect to water (temperature and chemistry), sediments (size distributions), ice (physical properties) and biota (effective surrogates or real vegetation);
- Improve wave generation hardware and software to correctly generate new, less common (more extreme), sea states;
- Improve current simulation for better representations of hydrographic changes in fluvial systems (e.g. simultaneous depth and velocity variations);
- Develop new techniques for measurement and analysis of flow and sediment behaviour, particularly in shallow flows, subsurface flows and aerated flows with high spatial and temporal resolution (e.g. run-up/overtopping, forces/pressure, flows with bed materials, morphology, etc.);
- Enhance the assessment of uncertainties through new methodologies and the provision of more extensive and detailed datasets;
- Exploit further advanced probabilistic methods for the modelling of long-term trends and extreme events;
- Develop reduced scale or miniaturised measurement equipment for both laboratories and the field;

Figure 2. Upper panel: Model setup in LNEC's (Laboratório Nacional de Engenharia Civil) flume. Lower panel: Model setup in FEUP's (Faculdade de Engenharia da Universidade do Porto) basin

- Continuously update predicted climate conditions using freely available data gathered at high resolution.

The main approaches to experiments that should be developed are as follows:

a) For the study of **coastal processes**:

- Long-term tests incorporating extreme events, storm event sequences and sea level rise;
- Tests on long-term behaviour of maritime and coastal structures affected by dynamic changes in forcing;
- Tests that incorporate mixed sediments and interactions of biota with sediment (scale 1:1);

Figure 3. Snapshots of the crack formation in ice sheets [10]

- Tests with natural and nature-based solutions;
- Experiments on flooding (storm-induced and/or surge-related) in cities and urban areas near the coastal zone by downscaling;
- Test series on beach recovery in climate change scenarios, including "soft" and "hard" coastal defence structures;
- Cost effective and manageable physical models to assess response to extreme events,
- Study of medium to long-term processes and climate change adaptation measures (Figure 2);
- Flooding and morphological risks in both mud-dominated and sandy estuarine environments with sea-level change;

b) For the study of **ice processes**:

- Increased wave dispersion and attenuation in the marginal ice zone;
- Permafrost-flux interactions and shore erosion due to permafrost thawing processes;
- Internal stresses in ice sheets and ice scouring due to ice ridges in shallow waters;
- Sediment transport by ice;
- Behaviour of structures frozen in an intact ice sheet which is subsequently broken by waves (Figure 3);
- Impact of reduced ice cover on coastal erosion;
- Modelling ice jams near river estuaries at the end of severe winter and start of very warm spring;

c) For the study of **fluvial processes**:

- Long-term river flume experiments to understand tipping points related to climate change forcing;
- Experiments on river flow and groundwater flow interactions, e.g. groundwater flow behind water defences, including interaction between flow and biofilm;
- Experiments with erodible banks to investigate channel change, bank failure mechanisms and flood impacts (Figure 4);
- Modelling of extreme events that may become more frequent as a consequence of climate change, such as flash flooding and drought conditions;
- Changes in vegetation resulting from climate change may result in increased or decreased growth rates for existing and/or new species, therefore experiments are needed to better understand the interrelationships between vegetation growth/decline and fluvial processes;
- The impact of native and invasive species on sediment erosion and bank stability requires more attention;

Figure 4. Morphodynamics responding to climate change trends over long timescales. Tagliamento River, Italy (Source: Jochen Aberle)

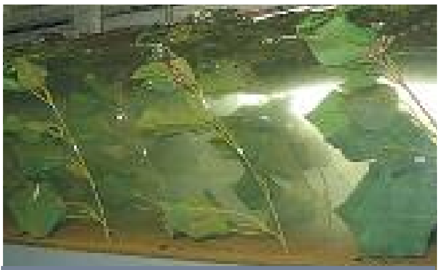

Figure 5. Surrogate vegetation in laboratory (Source: Jochen Aberle)

d) For the study of **ecohydraulics**:

- Tests using natural ecosystem characteristics to study bio-geochemical, biological, ecological and sedimentary interactions under extreme conditions for extended periods;
- Tests with surrogates to study the conditions needed to use them effectively (Figure 5);
- Tests to analyse the impact of environmental parameters on biomechanics that cannot be properly reproduced in our facilities today (light, climate, temperature, salinity, and acidification);

In summary, the physical modelling of the interactions between structures, waves, flows, sediments, ice, and biota need to be continuously developed and will remain essential for the improvement of our knowledge and understanding of hydrodynamics. The future will require greater focus on nonlinear and unsteady phenomena and on a wider range of spatial and temporal scales.

Acknowledgements

This work was developed under the framework of project HYDRALAB+ Adaptation for Climate Change, Task 6.1 of RECIPE, EC contract no. 654110. This paper was written with the contributions of those who participated in the Foresight Study Report [1] of Task 6.1, namely: Juana Fortes, Teresa Reis, Graça Neves, Francisco Taveira Pinto, Rute Lemos, Hannah Williams, Agustín Sánchez-Arcilla, Peter Thorne, Björn Elsäßer, Anne Lise Middelboe, Mikko Suominen, Mindert de Vries, Pierre-Yves Henry, Jochen Aberle and James Sutherland. ■

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ANNOUNCEMENT

1st ACCR International Conference on Coastal Reservoirs

Professor Tang Chair of the University Council and Founding-Chair of the China Chapter of IACRR

The 1st International Conference on Coastal Reservoirs will be held by Hohai University in Nanjing (China) in October 19-22th, 2020. Coastal reservoirs could provide a solution to the water problems of many coastal cities, but their successful development faces various challenges. These challenges require close cooperation between scientists, engineers, water resources managers and policy makers. In this regard, the conference will provide a forum bringing together participants from academia, consulting firms, local, provincial and national government agencies, and offering them an opportunity to interact in an informal and relaxed environment. The conference will provide students an opportunity to discuss with renowned and well-established researchers and professionals in this field.

Hohai University, founded in 1915, has the largest number of researchers studying water-related problems in the world and has gained worldwide reputation for its focus on water. Hohai is a state key university under the direct administration of the Ministry of Education of China. The university has been collaborating closely with various academic organizations including the International Association for Hydro-Environment Engineering and Research (IAHR). Seven colleges at Hohai are relevant to the topic of coastal reservoirs, including the College of Environment, College of Hydrology and Water Resources, College of Water Conservancy and Hydropower Engineering, College of Harbor, Coastal and Offshore Engineering, College of Oceanography, College of Civil and Transportation Engineering, and College of Mechanics and Materials. Professor Hongwu Tang, the Chair of the University Council and the Founding-chair of the China Chapter of the International Association for Coastal Reservoir Research (IACRR), cordially invites you to attend the conference.

The conference is co-sponsored by IAHR.
For more info please visit: www.IACRR2020.org

THE CHANGJIANG RIVER FLOOD PROTECTION PHYSICAL MODEL

BY JINYOU LU, SHIMING YAO & YONGHUI ZHU

The Changjiang River (formerly named the Yangtze River), is the largest river in China. The drainage basin of the river is a key area in China in terms of politics, economy, and culture with an abundance of water and mineral resources.

Despite this, frequent and severe floods from the Changjiang River are significant threats to the nation. For example, in the 20th century alone, four extreme floods occurred in the drainage basin of the Changjiang River; namely the 1931, 1935, 1954 and the 1998 big floods, which had devastating effects that significantly impacted socioeconomic development. The Three Gorges Project (TGP), one of the largest hydropower complex projects in the world, plays a key role for the improvement and development of the Yangtze River. The TGP started operating in June 2003, and improved considerably flood protection conditions in the downstream reaches of the river. However, the operation of the TGP also changed the hydrological regime of the downstream river and led to new conditions as outlined below:

(1) The decreasing sediment concentration in the river downstream of the TGP will induce scouring and silting over significant periods of time in the channel. Consequently, this will cause changes in the river flow regime and affect the security of dikes, slope protection works and river regulation works, etc.

(2) The scouring and downcutting of the channel downstream of the TGP and the corresponding decline of the water stage in the river will most likely change the flow and sediment diversion from the Changjiang River to the Dongting Lake via the “three outlets”; namely the Songzikou, Taipingkou and the Ouchikou (see Figure 1). The balance of the river-lake (i.e. Changjiang River-Dongting Lake) system will then be disturbed resulting in changes to fluvial processes and flood protection accordingly. Therefore, it was decided there was a need to build physical models for key flood protection sections of several river reaches in order to study the above mentioned issues in combination with numerical model simulations and prototype data analysis.

In 2003, the decision was made to build the Changjiang River Flood Protection Model (CRFPM) in Wuhan. The CRFPM, primarily consisted of large range physical model tests

Figure 1. Modeling area of the CRFPM

Similarities	Scales	Value of scale
Geometrical similarity	horizontal scale (α_L)	400
	vertical scale (α_H)	100
Flow dynamic similarity	velocity scale (α_v)	10
	roughness scale (α_n)	1.08
	discharge scale (α_Q)	400000
	time scale (α_{t1})	40
Sediment dynamic similarity	incipient velocity scale (α_{V0})	10
	particle size scale (α_d)	0.9
	fall velocity scale (α_w)	2.5
	sediment concentration scale (α_s)	0.75
	time scale (α_{t2})	135

Table 1. Summary of the model scales


Figure 2. Experimental hall of the CRFPPM


Figure 3. Control center of the CRFPPM

combined with numerical and prototype data analysis, in order to investigate the river-lake system evolution, the flood protection situation and the countermeasures for the middle and lower reaches of the Changjiang River after the TGP operation. The CRFPM aims at providing a scientific basis for flood protection planning, engineering construction and flood protection decisions. .

The Changjiang River Flood Protection Physical Model (CRFPPM) includes

- the Changjiang River from Zhicheng to Luoshan (about 400 km long), wherein the reach from Zhicheng to Lianhuatang (347.2 km long) is called the Jingjiang Reach,
- the Dongting Lake,
- the downstream end reach of the four main tributaries of the lake, i.e. rivers Xiang, Zi, Yuan and Li (see Figure 1),
- the three outlets and
- the many small channels connecting the Changjiang River and the Dongting Lake.

The horizontal and vertical scale of the CRFPPM is 1:400 and 1:100 respectively (see Table 1 for a summary of the model scales). Construction for the CRFPPM started in March 2004, and was basically completed in December 2005.

Facilities and equipment of the CRFPPM

The CRFPPM includes a 60,000 m2 experimental hall (Figure 2), the physical model, water and sediment supply system, control and measuring system and other relevant facilities such as the control center (Figure 3).

The choice of scaled sands used in the physical model tests is key to garnering successful experiment datasets. After more than two years of continuous testing and verification, special compound plastic model sands with various fine characteristics have been developed and produced.

The CRFPPM is equipped with advanced experimental measuring and control systems. The experimental automatic measuring and control systems consist of an observation and control network, measuring subsystems of flow rate, water stage, flow velocity, tailwater level, sediment supply, river channel topography, image monitoring and sediment analysis, etc. The systems are capable of real-time data acquisition and control and processing of various parameters during experiments.

Brief overview of research activities and achievements

After construction, verification of the CRFPPM was undertaken in 2006 to 2007. In 2008 the CRFPPM began to take on research projects. So far, more than 40 state, provincial or ministerial level scientific research projects have been conducted by the CRFPPM. Sources of funding for these projects are the National Key Research and Development Program of China, the National Natural Science Foundation of China, the Water Conservancy Pilot Study Program of the Ministry of Water Resources, the Special Funds for Scientific Research on Public Benefit of the Ministry of Water Resources to name a few. With these projects, key issues of the river after the TGP operation have been investigated and predicted, such as the flow kinematic characteristics, the propagation features of extreme floods, fluvial process and their impact on flood protection, water intakes along the river and the plan for river regulation works (Figures 4-6).

In addition to the above activities, the CRFPPM has also undertaken more than 100 various engineering research projects, such as the regulation of the navigation channel and bridge construction in the Changjiang River.

A number of high impact research findings have already been achieved through the implementation of these projects. Such findings have already been applied in the Comprehensive Plan of the Changjiang River Basin, the Plan for River Training of the Middle and Lower Reaches of the Changjiang River, the Master Plan of Follow-Up Work of the TGP, etc. The results have


Figure 4. Immovable bed model tests

also been adopted to guide the design and implementation of future river regulation works. The research results achieved during the verification stage of these hydraulic structure related projects (e.g. bridges, docks, water intakes and outlets) have not only been employed in the planning, design and construction of the projects, but more importantly also have provided the scientific basis and technological support for administrative licensing and management of the projects. During the period of 2008 to 2016, the research results achieved from the CRFPPM have been awarded more than 10 state, provincial or ministerial level prizes for progress in science and technology. Over 100 journal and conference papers have been published. Nearly 20 national patents have been authorized. More than 20 PhD or MSc students have graduated through various high impact research projects on the CRFPPM.

Figure 5. Movable bed model tests (with blue

Figure 6. Tests on the regulation of the navigation

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Rex Alfred Elder (1917-2018)

Rex A. Elder was a truly talented hydraulic engineer, whose career spanned decades of the 20th century critical to the development of hydraulic engineering. When it came to the hydraulics of hydro- and thermal-power systems, few (if any) engineers could match his perceptive, seasoned expertise and down-to-earth manner. Countless hydraulic engineers became acquainted with his contributions, and many engineers had the enriching experience of working with him.


Rex Elder at TVA in 1967

Rex passed away on February 24, 2018 at the remarkable age of 100. He was born on October 4, 1917, in the small town of Laquin, in northern Pennsylvania, where his father managed the local lumber mill. Rex grew up in the practical setting of a community centered on the regional lumber industry, which was struggling due to declining availability of timber and economic consequences of the Great Depression. His pragmatic disposition began early as he learned the lumber-mill trades and drove lumber trucks. In due course, he went to Pittsburgh's Carnegie Institute of Technology (now Carnegie Mellon University) where in 1940 he earned the bachelor's degree in civil engineering. He then attended Oregon State College (now Oregon State University (OSU)) where in 1942 he attained the master's degree in hydraulic engineering. That same year, Rex joined the Tennessee Valley Authority's (TVA) Hydraulics Laboratory.

By the end of WWII, TVA (created by the 1933 TVA Act) had completed a 1,050km navigation channel along the length of the Tennessee River, and had become the U.S.'s largest electricity supplier. During the ensuing years, Rex's career spanned major developments at TVA and in hydraulic engineering. These developments included TVA's substantial growth and milestone advancements in hydraulics theory, the use of hydraulics laboratories, associated instrumentation and modeling techniques, and methods for field investigation. The range of topics investigated played a critical role in TVA's Hydraulics Lab becoming the U.S.'s leading non-university, hydraulics lab during the years that Rex served as its director (1948-61).

At first, Rex was involved in a variety of technical activities engaging TVA's Hydraulics Laboratory. Then in 1948, he became the lab's director. Subsequently, in 1962, he was appointed Director of TVA's Engineering Laboratory, which investigated a broad range of engineering concerns. These promotions signified his talents as an engineer and ability to work with people. During Rex's thirty-one years at TVA (1942-73), TVA completed extensive studies for more than ten dams, a major pump-storage facility, six navigation locks, and sundry other hydraulics facets of TVA's expanding operation. His work on TVA's hydropower dams extensively involved the design of spillways, and inlet and outlet works. A project of which he was particularly proud was the spillway for TVA's Fontana Dam, a gravity-arch dam on the Little Tennessee River in North Carolina. The spillway, built during 1942-44, involved a tunnel through rock forming an abutment of the dam, and a flip-bucket ejecting flow emerging at the end of the tunnel. This project, addressing site difficulties, stimulated Rex's expertise in cavitation, flow resistance in tunnels, and overall aspects of spillway design. His work with locks along the Tennessee River led to a novel approach for filling and draining navigation locks. This new design, a multi-port manifold system, reduced lock filling time and lowered the cost of lock construction.

In 1952, TVA started on a huge program of power generation by coal-fired thermal-power plants, such that by 1955 coal surpassed hydro as TVA's main power source. Economic and environmental challenges began to emerge with widespread coal use, and energy demand was projected to keep expanding. Thus, in the mid-1960's TVA began to develop the use of nuclear reactors for generating electricity. TVA undertook the construction of Browns Ferry Nuclear Power Plant on the Tennessee River in Alabama. This power plant was TVA's first nuclear power plant and, at the time, one of few commercial nuclear power plants in the USA.

TVA's growth in the use of thermal-power led Rex to conduct early studies regarding various aspects of the interdisciplinary field now known as environmental hydraulics. With colleagues, he investigated the hydraulics of thermally stratified reservoirs and the design of water intakes to withdraw cooler water; they also conducted pioneering work on density currents, and on the hydraulics of diffuser-pipes for managing thermal-effluent discharges. The efficient operation of Browns Ferry Nuclear Power Plant motivated some these studies.

Rex retired from TVA in 1973 and joined Bechtel in San Francisco where he expanded and managed Bechtel's Hydraulics and Hydrology Group, which supported the design of multiple projects. In 1973, Bechtel had projects with approximately 20% of all of the U.S.'s new power-generating capacity and was extensively involved with overseas projects. Rex oversaw a sizeable number of engineers and hydrologists involved in a broad range of projects associated with hydro- and thermal-power plants, and hydraulics issues related to large-scale mining and industrial facilities.

These projects engaged Rex with talented Bechtel engineers and connected him to hydraulic laboratories and various hydraulics experts in the U.S., including those in academia. Throughout his career, Rex worked closely with hydraulics luminaries, such as Don Harleman (Massachusetts Institute of Technology), Jack Kennedy (University of Iowa), Norm Brooks (California Institute of Technology), Vic Streeter (University of Michigan), Bob Dean (University of Florida) and many others. Rex remained with Bechtel until he retired in 1985, though he continued to consult on sundry projects that interested him.

His concern for the advancement of hydraulic engineering led Rex to take on leadership roles in the U.S. and internationally. Rex was a Vice-President of IAHR (1984-87), and chaired several IAHR committees as well as committees of the American Society of Civil Engineers (ASCE). On a personal level, he easily befriended and mentored (capable) hydraulic engineers. Rex received multiple recognitions for his contributions to hydraulic engineering. In 1978, he was elected to the U.S. National Academy of Engineering, which cited his innovations in hydraulic research, design, and operation of large water reservoirs, river navigation facilities, and hydro- and thermal-power systems. ASCE bestowed on him its Rouse Award (1984) and Hydraulic Structures Medal (1991). In the 1980s, Rex became an Honorary Member and Fellow of ASCE, and in 2009 he became an Honorary Member of IAHR. Additionally, he became a member of the Hall of Fame at OSU's College of Engineering (1999) and a distinguished alumnus of Carnegie Mellon University (2007).

Several of Rex's publications have had substantial impact. In 1949, Rex, along with TVA colleagues Alvin Peterka and George Hickox, received ASCE's James Laurie Prize for their paper Friction Coefficients in Large Tunnels. This prize is named for ASCE's first president and is awarded annually to authors whose papers make a significant contribution to civil engineering. Rex's 1965 paper, coauthored with Don Harleman, Withdrawal from Two-Layer Stratified Flow, led to improvements in water-intake design for thermal power plants on lakes and reservoirs. His 1970 paper, Internal Hydraulics of Thermal Discharge Diffusers, written with TVA colleague Svein Vigander and Norm Brooks, substantially evolved the design of diffusers for wastewater effluents. An extensively referenced publication is a chapter that Rex and Bechtel colleague, Jack Cassidy, wrote for the book Developments in Hydraulic Engineering (Vol. 2, 1984); the chapter, titled Spillways for High Dams, remains widely consulted. By the way, the book was edited by IAHR Honorary Member Pavel Novak (1918-2018), who passed away on the same day as Rex; Novak too was a major figure in the engineering of hydraulic structures.

Rex's remaining family includes his four children: Jack, Carol, Susan and Will, as well as eight grandchildren and seven great-grandchildren. He was preceded in death by his wife of 66 years, Janet Alger Elder, and by his dear companion Mary Mackey. His son Will has established a website celebrating Rex's life: https://rexelder.life/, which depicts the many facets of Rex's enduring legacy to his family, friends and colleagues.

Pat Ryan, Duncan Hay, Angelos Findikakos, Jack Cassidy, Jacob Odgaard, Larry Weber, Suzanne Kennedy and Rob Ettema

SUSTAINABLE IRRIGATION WITH HYDRO-POWERED PUMPS

BY EMANUELE QUARANTA & JAIME MICHAVILA

Energy costs in irrigation have increased significantly in the last decade. In Spain, for example, by over 100%. Hydro-powered water pumps, called spiral pumps, are driven by the flow of rivers and canals and offer a sustainable and renewable alternative to electrical pumps. Spiral pumps are simpler, more cost-effective and produce energy reliably 24 hours a day. As a result, spiral pumps represent a viable and attractive option for pumping water, especially in rural areas and in developing countries.

Figure 1. Courtesy of Jaime Michavila (aQysta)

Hydro-powered pumps use the hydraulic energy of canals and rivers to lift water into reservoirs or provide pressurized water to drip and sprinkler irrigation systems (Figure1). As purely mechanical systems, they do not need electricity to operate, and can operate autonomously. A spiral pump consists of a pipe wrapped around a horizontal axle, forming a spiral tube, that is fastened to a water wheel. The water wheel is partially submerged in flowing water, so that the water in the river provides the energy necessary for the rotation of the wheel (Quaranta and Müller, 2018; Quaranta, 2018). When the inlet surface of the spiral tube (the tube external extremity) passes through the river or canal water level, water enters into the tube, while during the remainder of the rotation air is taken in (Figure 2).

The air volume trapped is compressed by the hydrostatic weight of the water column generated. Water and air columns move toward the outlet of the tube, the internal extremity of the tube, at the center of the wheel, where a rotary joint is connected to the straight pipe delivering water to the end-user. In this pipe, helped by the lower density of the air and the expansion of the previously compressed air, the water can be pumped at a higher elevation, Figure 3 (several times its diameter, unlike traditional "norias") (Tailer, P. 1990).

Although there have been past attempts to build such pumps in an artisanal way, aQysta, a start-up founded in 2013 by engineers from the Delft University of Technology in the Netherlands, was the first to develop a patent that allows to manufacture this pump as a commercial product cost-effectively. aQysta claims that its spiral pumps are able to pump to a maximum height of 20 meters and a maximum flow rate of at least 43.6 m3/day. As of May 2018, around 200 pumps were installed in 12 countries, such as in Nepal, Indonesia, Turkey, Zambia, Colombia and Spain (aQysta 2018). These pumps supply irrigation water to a total of around 200 hectares, benefitting around 5,000 people. aQysta has just been awarded an EU-

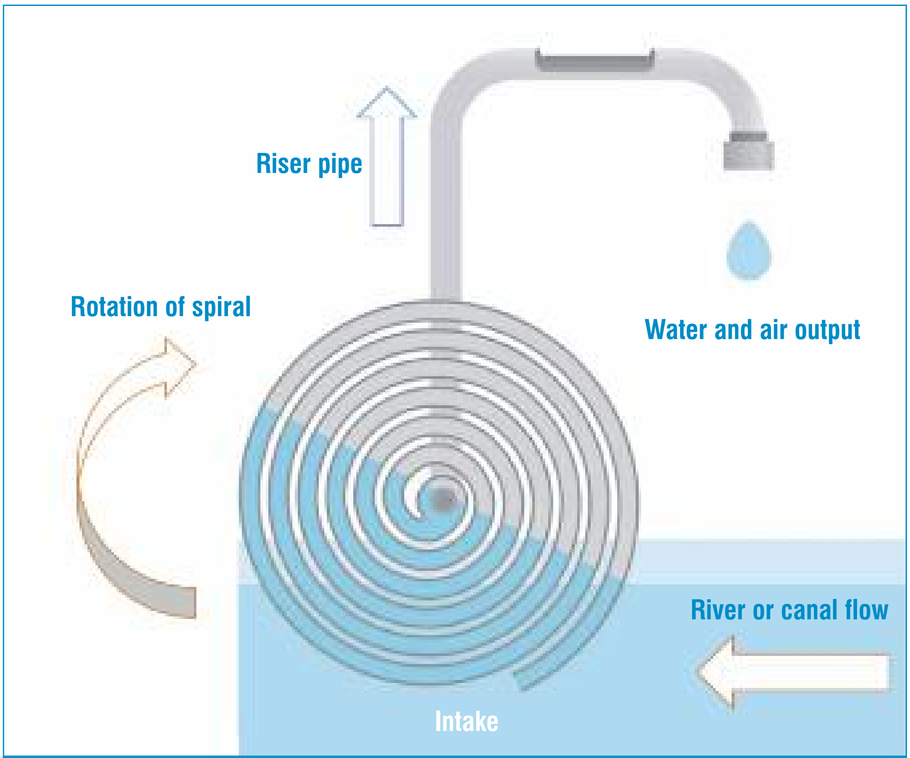

Figure 2. Courtesy of Jaime Michavila (aQysta)

funded Horizon 2020 project (named HyPump), as part of which demonstrators for developing a significantly more powerful pump are being conducted in Spain and Italy.
Given the simplicity of spiral pumps, and the fact that they can operate all day, as long as there is flowing water, they can be significantly cheaper to build, operate and maintain than solar-powered pumps. The payback period of spiral pumps is estimated to be 18 months shorter than for diesel pumps, and 4 years compared to that for electric pumps. In addition, using spiral pumps can reduce carbon dioxide emissions in irrigated areas by up to 500 kg/hectare-year. Spiral pumps save up to 70% of overall lifetime costs compared to diesel pumps, have no operation costs, require very modest maintenance and are environment-friendly. Therefore, they represent a promising technology that can contribute to more sustainable development, especially for irrigation use in rural areas.

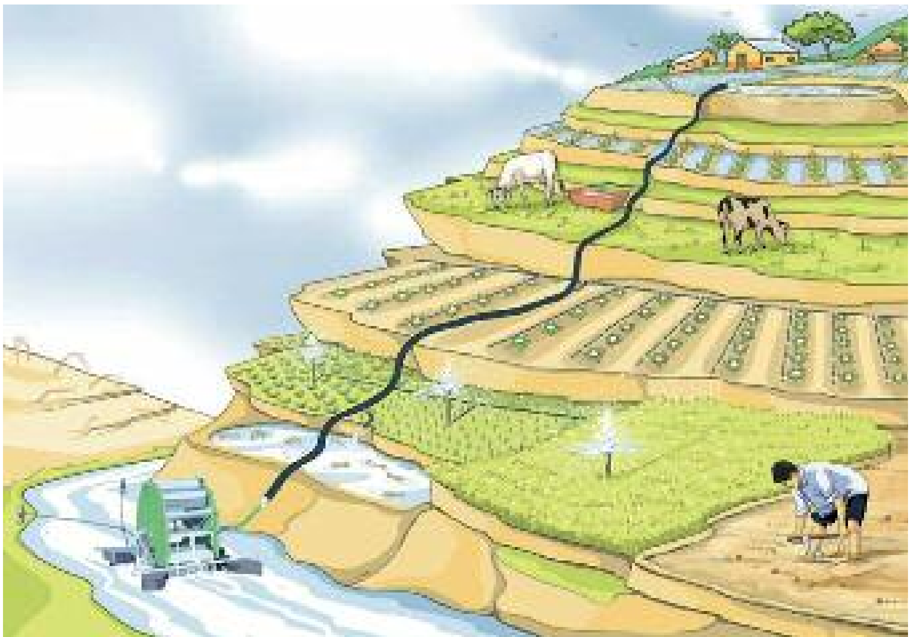
Figure 3. Courtesy of Jaime Michavila (aQysta)

Emanuele Quaranta, is a post PhD researcher and Hydraulic Engineer of Politecnico di Torino (Italy), and IAHR member. His scientific research deals with sustainable hydropower, with a focus on micro hydropower, water wheels and fish passages. He also works in CFD simulations. Emanuele is scientific consultant for companies, scientific divulgator, and he is collaborating with aQysta for the development of spiral pump technology in Italy. He cooperates with University of Southampton (UK), Katopodis Ecohydraulics Ltd (Canada) and he is Hydropower expert for the Joint Research Center of the European Commission. In 2017 Emanuele won the quality award from Politecnico di Torino. He is author of several scientific publications and educational articles on water wheel technology.

Jaime Michavila , (Madrid, 1986), is the lead hydraulic engineer of aQysta, a renewable energy water pump company based in the Netherlands, which among other recognitions was named in 2014 the most innovative clean technology startup in Europe. Industrial Engineer specialized in Mechanical Engineering by ICAI-Comillas, and Master in Technology Management by TU Delft. In 2009 he completed a year of exchange at the École Polytechnique Fédérale de Lausanne with a Universia-Fernando Alonso scholarship. He previously worked in the Innovation and Patents department of car manufacturer SEAT, the INSIA (Instituto Universitario de Investigación del Automóvil) in Madrid, and the Institut de Mécanique des Fluides de Toulouse. He has also been a Formula 1 reporter for the Autofácil and Car & Tecno motor magazines.

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IAHR AIRH

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Spain Water and IWHR, China

38th IAHR WORLD CONGRESS PANAMA CITY 2019

Water – Connecting the World

In the past number of years, global interest in water has peaked. Many water issues are high on the political and socio-economical agenda, ranging from topics concerning the lack of access to safe drinking water and sanitation through to the increase in water-related disasters due to floods and droughts.

On behalf of the Local Organizing Committee (LOC) of the 38th IAHR World Congress and the International Association for Hydro-Environment Engineering and Research (IAHR), we are delighted to invite you to attend the 38th IAHR World Congress in 2019 in Panama City, Panama.

The primary theme for the Congress will be "Water – Connecting the World", and shall focus on: Hydraulic Structures, Ports and Coastal Engineering, Hydro-Environment, Water Management and Hydro-informatics, River and Sediment Management and Climate Change and Extreme Events.

In addition to the dissemination of high-impact research findings through the above themes, the Congress will also provide a platform for academics (both in science and engineering) and practitioners to meet and engage to discuss important topics. The event will also host an exhibition to present the latest cutting-edge developments in equipment, software and instrumentation. Workshops and training events will also be offered throughout the Congress.

Call For Abstracts

Participants and presenters from every continent are encouraged to contribute regarding latest findings, best practice and innovation in Hydro-Environment Engineering and Research. When submitting your abstract, please choose the theme/topic below that is most appropriate to your research:

THEMES / TOPICS

Theme A – Hydraulic Structures	Theme E – River and Sediment Management
Theme B – Ports and Coastal Engineering	Theme F – Climate change and Extreme Event
Theme C – Hydro Environment	Theme G – Other Related Themes
Theme D – Water Management and hydro-informatics	

Guidelines for Abstract Submission

Authors are invited to submit their abstracts electronically based on one the 7 themes listed for review by the Congress Scientific Committee. Abstracts should be in English and of 300 to 400 words. One author can submit no more than two abstracts as the first author. The authors of the accepted abstracts will subsequently be requested to submit the corresponding full-length papers according to the Key Dates and Deadlines outlined below.

KEY DATES AND DEADLINES

Abstract Submission	October 28, 2018
Abstract Notification	January 27, 2019
Paper Submission	April 16, 2019
Paper Notification	June 18, 2019
Congress	September 1 to 6, 2019

More than just a Canal

About Panama City (PTY)

A strategic point for air connections between the Americas, with a skyline filled with contemporary architecture, Panama City is well known for its business infrastructure, cosmopolitan culture and biodiversity. The Panama Canal, only fifteen minutes from downtown Panama City, is one of the most important engineering works of the 20th and 21st century.

Panama is a country of diversity and contrasts; a country of multiple atmospheres, diverse in the historical, geographical and cultural aspects, and inhabited by a colorful mixture of ethnicities and customs. Because of this unique combination of people and extraordinary sites, Panama City is a magical and fascinating destination.

Technical Visits

A number of technical visits have been arranged with the assistance of selected local travel agencies/partners, who handle planning, booking and the visit itself.

Atlantic Technical Tour
Agua Clara New Locks
Duration: 8 hours approx.

We will travel along the Panama Canal by the Transisthmian Railway, beginning at Panama City (on the Atlantic Side) and ending at Colon Province on the Caribbean side. Once we arrive at Colon, we will visit the two sets of Locks called theAgua Clara Locks, where you will have excellent views of the Panama Canal . The Agua Clara Visitor Center offers an impressive panoramic view of the Panama Canal Expansion in the Atlantic region and provides fulfilling experience to understand all the development and construction of the Panama Canal expansion project.

Pacific Technical Tour
Panama Canal Partial Transit
Duration: 7 hours approx.

This tour gives you the opportunity to transit one set of locks. Departing from Flamenco in Amador, the journey takes you into the Miraflores Locks where the water is raised up to 54 feet in a two step process. This process is achieved by conveying water from Pedro Miguel's lake by gravity to fill the chamberswhere the ship is locked. Once the process is finished, the ship proceeds onto Pedro Miguel´s lake.Calling at Gamboa, you are then transferred to a bus to return to your hotel approximately. The tour includes dinner and drinks.

Bay Sanitation Project
Duration: to be confirmed

This tour gives you the opportunity to experience the Panama bay Sanitation Project. The treatment plant of the Sanitation Project of the City and the Bay of Panama is located in the south east area of Panama City, specifically in the area of Juan Diaz
The Panama Bay Sanitation Project is a state project aimed at tackling the problem of wastewater i, discharge to streams, rivers and tributaries which once caused significant environmental damage and generated health risks for the population.
The project includes an interceptor tunnel(8.1 kilometers long and 3 meters in diameter), which has the function of conveying wastewater from the collectors to the pumping station in Nuevo Reparto Panamá at a level of 25 meters deep. It also includes a Line of Drive that takes the waters to the treatment plant of Juan Díaz. The plant receives and treats wastewater generated in the capital and in the district of San Miguelito, allowing clean effluent discharge to return to the Juan Díaz River.. Through the treatment process, methane gas is recovered which is used to generate 18% of the electrical energy required by the plant during operation.

Miraflores Visitor Center & Frank Gehry Museum
Duration: 4.5 hours approx

Visit the Miraflores Locks Visitors Center, where you can take the opportunity to pause and view the enormous ships that make their way through the Panama Canal. Visit the four exhibition halls, organized by themes that constitute the heart of this center.
Enjoy a spectacular view of the famous Panama Skyline while traveling via the Causeway to the former Fort Amadorenroute to the Frank Gehry Museum. The Amador Causeway was built from excavated material during Canal construction; it took 18 million yards of solid rock extracted from the famous Culebra or Gaillard Cut of the Panama Canal to build this Causeway. The Causeway was formerly part of a military base, which has been now transformed into a flourishing tourist attraction and marina.
Visit the Biodiversity Museum and explore the only building designed by Frank Gehry in Latin America and Panama to understand how the planet was impacted when Panama merged to connect the Americas. From the Biodiversity Museum it is possible to clearly see the profile of the modern city, the Old Town, the "Cerro

Tourist Attractions

The Congress location will provide every participant with a lifetime of memorable experiences including:

Visit Panama, Old City
Enjoy the rich and historical character of traditional Panama culture on a guided tour that highlights the nation's past, present and future life. Visit the Causeway area where you can appreciate beautiful Sunsets, while having a gorgeous view of the Pacific Ocean.

Visit Rainforest and Chagres River
Take an adventure through a mile long path that lies within the Gamboa Rainforest boundaries. By tram you will ascend 280 feet which ends on the top of a hill whereyou can walk to the observation tower.From there you´ll get great views of the Canal and the Chagres River, as well as the surrounding forested areas of Soberania National Park. After this, you will take a small boat trip to visit the Monkey Island at Gatun Lake.

Embera's Indigenous Community
Experience hopping on a boat and sailing through the Chagres River into the Embera´s indigenous community located at the Chagres National Park. Upon arrival at the village, you will experience and learn about the traditional way of life of the indigenous culture There.
You may also take a rainforest tour to a waterfall, visit their homes, experience traditional dancing, customs and understand their culture and lifestyle.

The 38th IAHR World Congress will bring together the key players in the sector from around the globe involved with "Water – Connecting the World", from 1-6 September 2019 in Panama.

We look forward to meeting you there!

Visit our Website
http://iahrworldcongress.org/

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The Intelligent Management Platform of Model Yellow River

As an important part of Sinfotek's WIM platform, "Model Yellow River" intelligent management platform can take advantage of modern information technologies of Internet of things , multimedia and virtual simulation to achieve the management of model test materials, equipments, test processes and scientific research achievements, provide technical support to the existing management services of “Model Yellow River” and enhance the level of intelligence management.

[Note：WIM system（Water Intelligent Management）]

The Internet of things technology, the laboratory on the fingertips

The technology of Internet of things can realize wireless interconnection of measurement terminals, control terminals, display terminals and testers, the wireless transmission of experimental data and real-time display of experimental results. The experimental process can be easily controlled.

Three-dimensional information technology of laboratory,comprehensive display of experimental information

It applies electronic sand table technology, builds laboratory Lab-BIM system, combines 2D and 3D laboratory engineering information, realizes the comprehensive display of model scenes, section information, instruments and monitoring data.

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