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Picture: Google Earth Engine

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THE INCREASING USE OF SATELLITE DATA IN SUPPORT OF WATER MANAGEMENT AND STUDIES

EDITORIAL BY ANGELOS N. FINDIKAKIS

Angelos N. Findikakis
Hydrolink Editor

The use of satellite data has contributed significantly to the understanding of changes in environmental conditions around the world and the management of natural resources. The use of satellite imagery in water studies increased rapidly after 2008, when the National Aeronautics and Space Administration (NASA) of the United States made publicly available for free all imagery since the launching of its first Landsat satellite in 1972. Taking advantage of the availability of these data at no cost, many organizations started using them routinely to support water resource management decisions. The development of special algorithms has made it possible to analyze the images to estimate evapotranspiration, which provides a measure of water use in irrigated areas. In areas where agriculture depends on rapidly depleted aquifers this information is used to assess compliance with restrictions in groundwater pumping. Estimates of evapotranspiration developed based on satellite data have also been used as input to groundwater models supporting the management of aquifers. A report of the United States Geological Survey reviewed different applications of satellite data in water resources, including water use assessment, optimizing irrigation, streamflow water rights, and water dispute settlements (Serbina and Miller, 2014). Many of these applications have been in the western United States, but also in other parts of the world, such as the Talca Valley in Chile, the Tadla region in Morocco, and the Murray-Darling basin in Australia. Landsat images have also been used in combination with other remote sensing technologies and geophysical, geologic and other data to successfully locate potential groundwater resources and identify target areas for drilling water supply wells in arid areas. A well-publicized success story was the use of this approach to determine where to drill water supply wells for the needs of the hundreds of thousands of internally displaced people following the 2004 Darfur crisis in Sudan. Earlier this year, the Food and Agriculture Organization (FAO) of the United Nations introduced a new tool, the Water Productivity through Open access of Remotely sensed derived data (WaPOR), that uses satellite data in combination with other information to monitor and report on water productivity in agriculture over Africa and the Near East and help farmers improve productivity and optimize the use of irrigation systems (FAO, 2017).

A major step towards the wider use of satellite data for the study and management of natural resources was the launching by Google of the Earth Engine platform in 2010. Earth Engine makes available online a very large volume of current and historic satellite imagery and data covering the entire planet, along with computer resources and analytical tools. Many research groups have already taken advantage of the availability of these data, resources and tools and partnered with Google to develop special applications for the study of water problems. The use of Earth Engine has made it easier for these groups to share datasets and code and collaborate with other scientists and developers around the globe to solve real world problems. This issue of Hydrolink includes an interview with Dr. Tyler Erickson, Senior Developer Advocate at Google and Water Cycle Analysis Lead for Earth Engine, who describes some of these applications and explains that Google is encouraging its partners to suggest specific data sets that should be uploaded in its online database. One of the applications discussed in this interview is the Climate Engine Application designed to process and visualize satellite and gridded weather data for environmental monitoring and to provide early warning of droughts, wildfires, and risks to agricultural production. In his interview Dr. Erickson expresses his excitement about the trend towards more open data and open source development practices.

A very interesting application developed using Earth Engine is the Deltares Aqua Monitor described in the article by Donchyts, Baart, Winsemius, Gorelick, Kwadijk and van de Giesen. Aqua Monitor, an open source application, freely available on the internet, allows users to visualize and quantify changes between land and water surfaces based on satellite data during any period between 1985 and 2016. This application makes it possible to easily quantify year-to-year changes in inland water bodies, such as the Aral Sea or the lakes on the Tibetan Plateau, but also in coastal areas where erosion and accretion cause continuing changes in the shoreline. In the year since its introduction Aqua Monitor has been used by several researchers to support their work in a broad range of subjects from changes in delta regions to the sustainability of oases in areas of intense groundwater use.

The availability of platforms, databases and tools like those offered by Earth Engine and open software online applications like Aqua Monitor allows an increasing number of researchers to investigate and solve water problems around the world, problems whose study was very difficult in the past. The same tools allow managers and policy makers to make more informed decisions in the management of water resources and the development of mitigation measures for water related risks. Finally, freely accessible and user friendly online applications employing satellite and other data to identify changes in the water environment and resources offer an excellent way to educate the public at large on these issues.

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Cover picture: Surface water transition classes from the Mekong Basin Delta, Cambodia and Vietnam. Source: EC JRC/Google (https://global-surface-water.appspot.com)

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GOOGLE EARTH ENGINE

INTERVIEW WITH TYLER ERICKSON

The Earth Engine platform, launched by Google in 2010, makes available online a very large volume of current and historic satellite imagery and data covering the entire planet, along with computer resources and analytical tools. Since its introduction several research groups and other organizations have partnered with Google to use it for the study of natural resources and environmental changes in different parts of the world. The Earth Engine platform has already been used to develop several applications supporting the study of the water environment. Hydrolink had the opportunity to interview Dr. Tyler Erickson, Senior Developer Advocate at Google and Water Cycle Analysis Lead for Earth Engine, who is also a featured keynote speaker at the 37th IAHR Congress in Kuala Lumpur. In this interview, Dr. Erickson answers several questions of special interest to the audience of this magazine.

Can you give a brief overview of what Earth Engine is?

Earth Engine is a cloud-based geospatial data analysis platform. Cloud-based means you have rapid access to petabytes of data co-located with large amounts of computer resources. Geospatial means that the system is optimized for working with spatial data that is referenced to the Earth's surface, and that allows you to easily combine data from multiple sources: satellite data, gridded model predictions, surface observations, natural or political boundaries. Analysis platform means that it is designed so that developers can customize it for their own specific use cases, by accessing Earth Engine's data storage and analysis functionality via application programming interfaces (APIs). The Earth Engine team maintains a few general purpose web applications using the APIs, but many organizations build and maintain their own domain specific applications.

What projects related to water resources are under way by Earth Engine partners?

Earth Engine partners are working on many projects throughout the water cycle, but a few areas stand out with a particularly large amount of activity. One focus area is mapping the occurrence of surface water resources and how they are changing over time. For example, scientists at the European Commission Joint Research Centre (JRC) have used Earth Engine to map the occurrence of surface water globally over 32 years at a monthly time scale and a 30-meter spatial resolution, based on imagery collected by the Landsat satellites. The JRC released the resulting dataset via an application that allows users to interactively visualize the dataset in space and time, as well as download the dataset under an open license for further analysis. The resulting dataset is also made available in Earth Engine so other developers can build analyses and applications on top of it. A small example of one of the layers in the dataset is shown in Figure 1.

Another exciting focus area is mapping variations in evapotranspiration (ET) for monitoring water consumption by agriculture. Several different ET algorithms, using a diverse set of remote sensing data sources, are currently being implemented in Earth Engine. Once available, these algorithms will improve the monitoring of water use at a global scale at high resolution.

Other analyses of the water cycle that partners are conducting with Earth Engine include monitoring land cover changes in watersheds, characterizing drought, building historical climatologies of flooding, and monitoring water quality of inland surface waters.

Do you have plans to compile/organize in the Earth Engine database any other water-related data from different sources around the world?

It largely depends on the interests of our partners, which we take into consideration when prioritizing new additions to the Earth Engine Public Data Catalog. Partners are encouraged to nominate new datasets and vote on existing nominations. Providing details on what could result if the dataset were made available in Earth Engine can help boost the prioritization. Of course, partner interest is not the only criteria that is taken into account. We prioritize datasets that have liberal licenses that do not restrict how others can utilize of the data. We believe in open science and open development and work to provide tools that make it easy to share source datasets, analyses, and results.

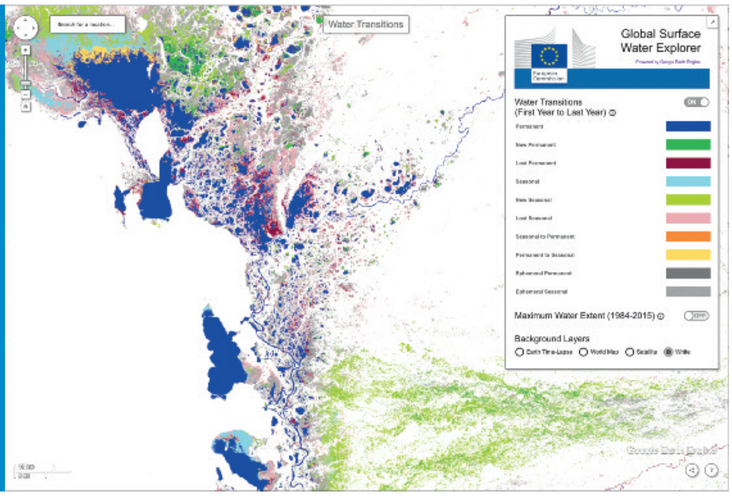

Figure 1. Surface water transitions layer of the Global Surface Water dataset for the Paraguay River floodplain on the border between Bolivia and Brazil. Source: EC JRC/ Google (https://global-surface-water.appspot.com)

In terms of datasets that may be useful for water-related analyses, recent additions to the Public Data Catalog include the Global Land Ice Measurements from Space (GLIMS) dataset of 200,000 glacier boundaries, the USGS Watershed Boundary Dataset, and the United States Department of State's Large Scale International Boundary (LSIB) Lines dataset.

Are there any Earth Engine projects under way that address issues related to climate change, especially its impact on water resources?

One interesting project is this area is Climate Engine (ClimateEngine.org), a web application for analyzing changes in gridded climate, weather, and satellite remote sensing datasets. The Climate Engine is being used to characterize climate changes over the last few decades in the western United States, monitor life-threatening drought conditions in Africa, and improve water management for mining operations and reclamation.

At present I feel that the potential for climate analysis in Earth Engine is still largely untapped and will grow as more climate-specific datasets are added to the catalog. One recent addition in this area is the NASA NEX Global Daily Downscaled Climate Projections (NEX-GDDP) which provide downscaled 0.25 degree daily projections of temperature and precipitation from 21 climate models and two emissions scenarios.

How do you see Earth Engine contributing to achieving the Sustainable Development Goals (SDGs) set by the United Nations in Agenda 2030?

One of the goals of the Earth Engine project is to make substantive progress on global challenges, and the UN SDGs are about the best list of global challenges compiled by international experts that I can think of. The main way I see Earth Engine contributing to achieving the SDGs is by supporting partners that are already working to address specific targets associated with the goals, by helping scale up their work to cover larger areas and handle larger and larger datasets. Water factors into many of the SDGs, not only as directly called out in Goal #6 Clean Water and Sanitation, but it also is critical for the goals of ending hunger through sustainable consumption, combating infectious diseases, preventing degradation of land cover, and building resilient infrastructure for sustainable cities. We are already adding relevant datasets that our partners have requested to address SDGs, such as global population and socio-economic datasets.

Are you planning to make all the data in Earth Engine available for visualization in Google Earth?

Earth Engine data can already be viewed in Google Earth by using KML files, an Open Geospatial Consortium (OGC) standard for geospatial visualization and annotation that is used by Google Earth and other earth browsers. Vector datasets can be exported directly from Earth Engine as KML files. Raster data can be exported as image files and draped on Google Earth using KML GroundOverlay elements. In the future we (or some Earth Engine developer) might create tools to make it easier to produce KML files for complex visualization, if it becomes apparent that this is a barrier that our user community cares about.

On a related note, the 700 trillion pixel cloud-free basemap image that you see in Google Earth when zoomed out to regional or continental scales was produced with Earth Engine, using the same tools that we make accessible to scientists and developers.

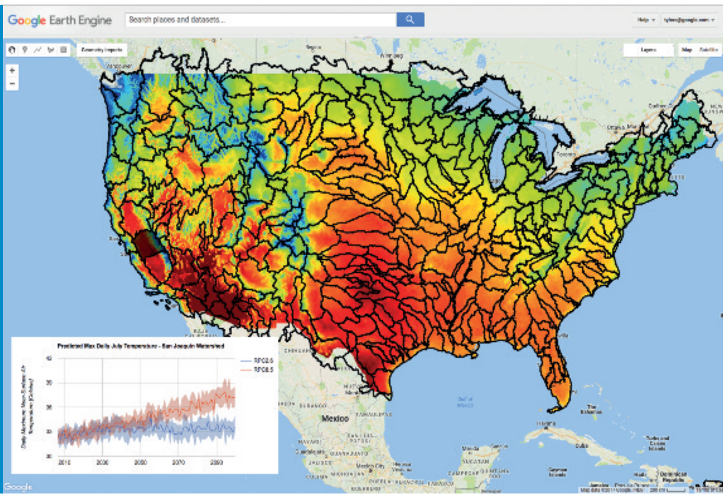

Figure 2. Map showing predicted maximum daily surface temperature for July for an emission scenario (RCP 2.6). The chart in the insert compares predicted maximum surface temperatures for two emission scenarios (RCP 2.6 & RCP 8.5) for the San Joaquin watershed. Dataset sources: NASA NEX-DCP30, USGS Watershed Boundaries

***Dr. Tyler A. Erickson* is a Senior Developer Advocate at Google. In this role, he fosters collaborations with researchers from academia, NGO's, and governmental organizations seeking to capitalize on Earth Engine's capabilities for geospatial analyses that involve immense satellite and model-based datasets. Dr. Erickson leads the development of Earth Engine's core efforts in water and climate, and guides the evolution of Earth Engine to support these scientific domains. A snow hydrologist by training, he has degrees civil and environmental engineering and geography degrees from Colorado State University, CalTech, Stanford, and the University of Colorado at Boulder.**

What's exciting for the future?

One thing that has been exciting for me is seeing developers rapidly deploy applications soon after we add features to Earth Engine. For example, in August 2015 we announced that Copernicus Sentinel–1 radar data had been added to the Earth Engine Public Data Archive. Less than a month later, Pakistan's SUPARCO's Space Application Center for Response in Emergencies and Disasters was blogging about how they were using Earth Engine and Sentinel-1 for rapid inundation analysis of the 2015 flooding events. As we continue to improve our tools for working with large geospatial datasets I look forward to this rapid development becoming more common.

I continue to be excited to see that more and more data providers and developers are adopting open data and open source development practices. They are seeing that that real value is not in collecting data or creating algorithms, but value is realized when the data or algorithms get used for a beneficial purpose. By utilizing cloud technologies such as Earth Engine, it becomes very easy to share datasets and code, and this has facilitated collaborations between scientists and developers working all over the world. And when it becomes easier to collaborate and share work, scientific progress and real world results happen at a much faster rate. ■

THE DELTARES AQUA MONITOR

BY GENNADII DONCHYTS, FEDOR BAART, HESSEL WINSEMIUS, NOEL GORELICK, JAAP KWADIJK & NICK VAN DE GIESEN

Has the world become wetter or dryer? Can we see global trends in the changes of coastlines, and are these trends also apparent where we live? Is the total surface water storage on land growing or shrinking? These are rather simple questions, but have so far been hard to answer, and yet are important in order to understand the dynamics of our planet and the attribution of these dynamics to climate anomalies, and climate or man-made change. Answering these questions requires the availability of global maps at a very high resolution, which are very accurate and updated frequently. Remotely sensed Earth Observation (EO) data, such as satellite imagery, can obviously be used for this purpose. The volume of such data is increasing exponentially . To store, handle and analyse these data on a global scale requires a combination of access to enormous data storage and high-performance computers. It would require man-years working on the data preparation, exploring algorithms before the actual analysis, could be started. Until recently, such analyses could only be performed by highly specialized scientists and engineers, and on a case-by-case basis. The Deltares Aqua Monitor is a game changer showing that this situation is rapidly changing. It also shows that the way we analyse and use these data differs from what was common practice until very recently.

What is the Aqua Monitor?

The Aqua Monitor (DAM) is an open tool that analyses satellite data and visualizes land and surface water changes around the globe.

Where figure 1 shows a global picture, opening DAM on the internet allows the user to zoom-in to a maximum resolution of 30 meters and change the analysis periods to user-defined years. Downscaling (interpolation + smoothing) techniques are used to generate contours with an even higher resolution. DAM bridges the analysis from the global to the local scale. Those who live in a river delta can inspect erosion and accretion patterns over the last 30 years. In Egypt, one can inspect how lakes and reservoirs have varied in the Nile basin upstream. In Bangladesh, one can see how much the Brahmaputra River has changed its course over the last 5 to 30 years.
We used DAM to estimate the changes in the

Figure 1. Heat map of global surface water and land changes. Bright blue lighting shows where land was converted into water over the period 1985–2015. Bright green lighting shows where water was converted into land over the same period. The intensity of the colours highlights the spatial magnitude of the change

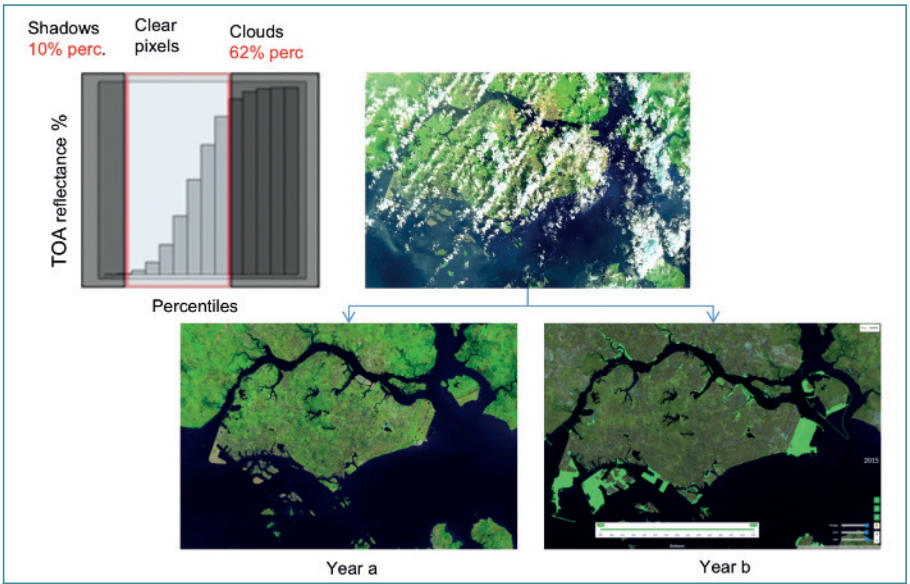

Figure 2. In Singapore the Aqua Monitor shows the effect of the land reclamation by combining information from different images covering the same area for each pixel, thus providing a probability for changes from land to water and vice-versa is calculated through linear regression analysis. Bright green colours represent areas where water was converted to land

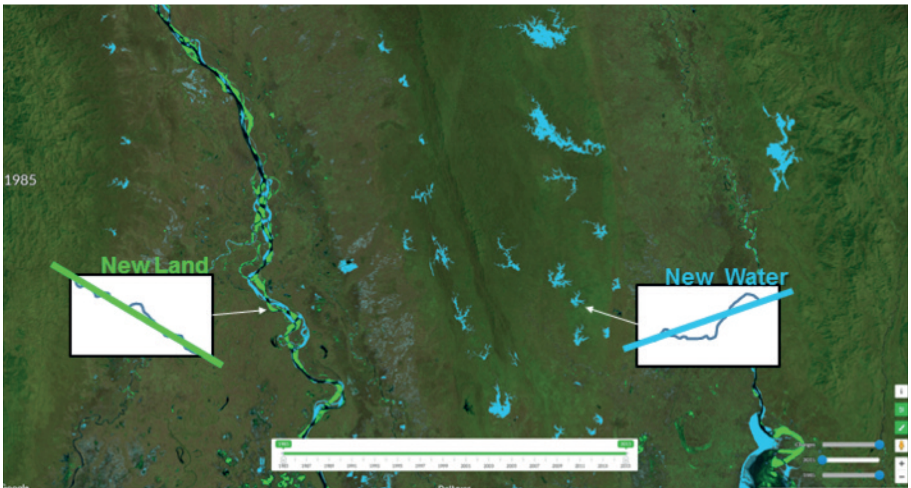

Figure 3. In the area of Myanmar the Aqua Monitor shows the transition of land and water between 1985 and 2000 due to changes in river courses (left) and damming of rivers (right)

earth's water and land surface over the last 30 years. According to our estimates, 115,000 km^2 of land disappeared and 173,000 km^2 of land emerged. In coastal areas 20,135 km^2 of land converted into water and 33,700 km^2 of new land emerged from the water. The large contributors to changes in the global surface water are the Aral Sea, where we find the largest inland transition from water to land, and the Tibetan Plateau where we find the largest increase in new permanent surface water at the cost of land. In the Chinese coastal areas we find large gains of land due to land reclamation from the sea.

How does the Aqua Monitor work?
DAM makes use of the complete Landsat satellite imagery . Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. It spans almost 40 years of continuous monitoring from space at a resolution of 30 meters and imaging each location about once every two-three weeks. DAM approaches these data via Google Earth Engine. Google Earth Engine is a multi-petabyte scale processing platform that harmonizes access to various free satellite imagery acquired by multiple satellite missions such as NASA Landsat, MODIS and ESA Sentinel. The platform also makes analysis capabilities available free of charge for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface.

DAM combines time series acquired by multiple Landsat missions covering the same area to identify transitions between surface water and land globally. Multiple images are needed because clouds are often hiding parts of the land surface. By combining information from different images covering the same area for each pixel, a probability for changes from land to water and vice-versa is calculated through linear regression analysis. By doing this repeatedly over all years, changes from land into water and vice versa can be determined. DAM highlights those areas where water has converted into land as bright green, and where land changed into water as bright blue. Figure 2 shows an example in Singapore where several water areas were converted to land due to land reclamation projects.

Another application of DAM is presented in Figure 3, which shows conversions from land to water and vice versa between 1985 and 2015 in Myanmar. In the western part of Figure 3 the changes are due to (natural) changes in the course of the river, while the eastern part of this image reveals new reservoirs originating from the damming of rivers. Most of these reservoirs are not reported in international dam and reservoir databases.

All calculations of the Aqua Monitor are performed on the fly by the Google Earth Engine infrastructure. In the past, satellite data were normally downloaded to a local computing environment for further handling. Here, all data used for the analysis remains where it is stored, i.e. in the cloud. The algorithms are written in the script language of Google Earth Engine allowing processing of large volumes of data on the fly, and reducing the amount of data to be transferred to the user. In Aqua Monitor the model is brought to the data, instead of downloading the data to use as input to the model. Through a smart data storage model, only the area zoomed into, and the pixels fitting on screen are considered for computation, which reduces the computation time and minimizes the data transfer over the web. In this way, many people do have access to the model and can perform analyses of their interest. The interface is such that people do not need any special knowledge of remote sensing and image analysis to handle DAM.

Aqua Monitor illustrates how emerging cloud platforms for large satellite data analysis, are rapidly removing the thresholds to the use of planetary-scale data. Successful platforms, such as Google Earth Engine, provide access to earth observation data in three ways: by (a) the storage of satellite data in the cloud; (b) provision of computational resources and (c) the availability of analytical tools to process data into a clear end product.

What does Aqua Monitor support

Bridging scales for everyone: Aqua Monitor bridges the global and the local scale. Using one freely available instrument, every internet-connected person can investigate changes in water on the global scale, as well as in their own neighbourhood. Aqua Monitor provides an objective source of information on surface water resources, coastal erosion and accretion, brought at everybody's fingertips, regardless of their knowledge of image processing.
For example, many countries report on their dam construction, but the information provided is far from complete. In Myanmar, the Global Reservoir and Dams database shows an increase in water surface between 1985 and 2010 of about 400 km^2. Using the Aqua Monitor, we have counted the appearance of 1,180 km^2 of new water.

It helps to identify (causes of) changes that were difficult to identify before: Aqua Monitor does not provide information on the cause of changes directly. But in some cases, the patterns it reveals help improve the understanding of the causes of such changes.
An example is the case of some lakes on the Tibetan Plateau which are known to be growing. Different researchers have studied the history of these lakes on a case by case basis. Many suggested glacier mass loss as the cause of the increasing lake area. Using the Aqua Monitor one can visualize the vast extent of the growing lakes.

Figure 4 shows that almost all lakes have grown in size since the end of the last century. Since not all lakes are connected to rivers that drain glacial basins, glacier melt cannot be the single cause. Given the extent, a trend towards wetter climate conditions seems to be a more reasonable explanation .

What does the Aqua Monitor mean for science

In our view DAM is one of the first examples of how the increase in volume of EO data and ease of access to these data could lead to changes in the way environmental studies are performed. Due to its simplicity in use and openness, the Aqua Monitor allows for collaborative science. Aqua Monitor provides the means to perform crowd-sourced science and enables the development of public science. When we published the Aqua Monitor in August, 2016, we asked several researchers to review its results for areas where they do research and to provide ideas in what they could do with it.

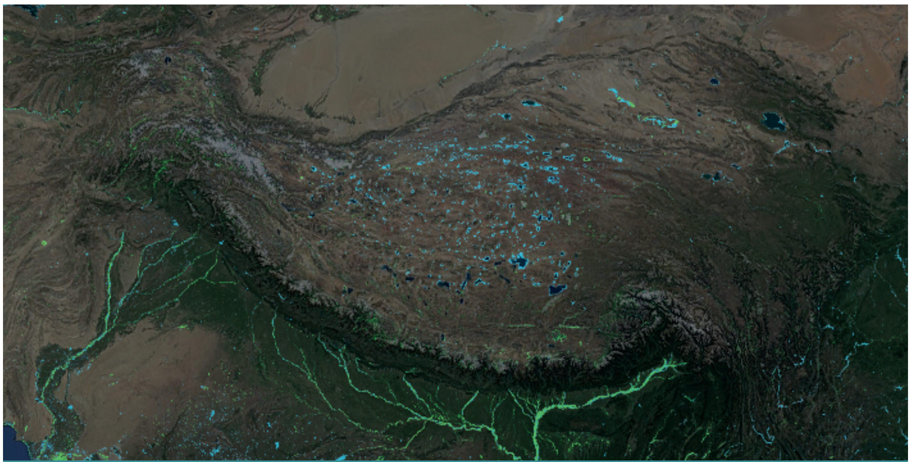

Figure 4. The Aqua Monitor shows the increase of surface water area on almost the entire Tibetan plateau between 1985 and 2015

Aart Kroon from Denmark, looked at some specific areas, where surface water changes occurred due to 'nature-reestablishment' (Filsø in Western Jutland). The changes include the creation of man-made barrier islands (Amager Beach Park in Copenhagen), the creation of the large bridges over the StoreBælt and Øresund (with Sweden), and the extension of harbour moles like those in Køge. The patterns of natural developments he studied were covered by Aqua Monitor and were in line with traditional monitoring techniques. He also looked into the shorelines of Alaska, as well as the mudflats of Guyana and Surinam. He concluded that the pattern of change according to Aqua Monitor is in line with those described by others (for Alaska recently by Gibbs and Richmond in 2015), although the Aqua Monitor may underestimate the recorded drowning at the Alaska coast.

Steffen Zacharias from Germany, tested Aqua Monitor around Leipzig. Here the fall of the iron curtain had tremendous implication on the East German lignite industry. As a result, the majority of the open pit mining activities were stopped. Most of the now redundant open-cast mines have been flooded since around 2000. This created many large lakes in the area around Leipzig. The increase of the lake areas is perfectly visible in Aqua Monitor and can be even visualized in time.

Tom Gleeson from Canada proposed a series of possible applications on groundwater. These applications included the role of springs and seeps in ecology and human evolution, the sustainability of oasis in regions where groundwater is being heavily used (e.g. North Africa) and the expansion of groundwater-irrigated agriculture. Figure 5 shows an example for the Lake Chad region illustrating that trends may be very complex. The blue colours southwest of

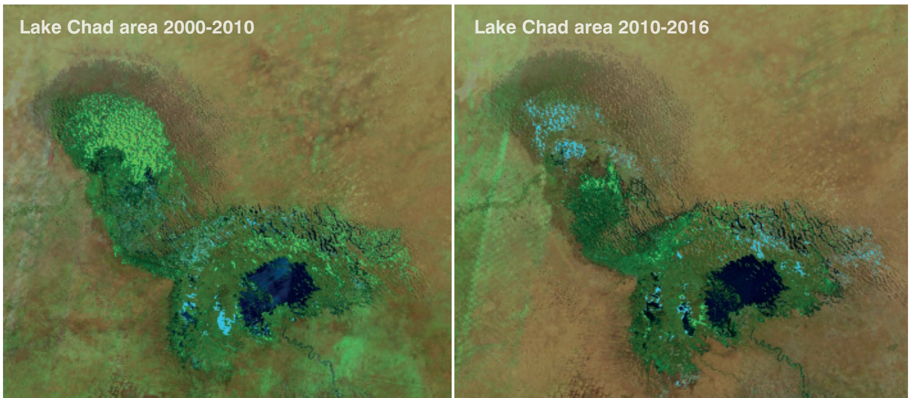

Figure 5. DAM shows the average changes in surface water over two distinctive periods in the Lake Chad area, illustrating trends in surface water areas can be complex, even in one area

Gennadii Donchyts **is a senior consultant at Deltares. He has a multidisciplinary background, covering the development of environmental modeling software and design of remote sensing algorithms for multi-spectral satellite data processing. Since 2013 Gennadii is pursuing a Ph.D. at the Technical University of Delft on a part-time basis, where he uses parallel satellite data processing platform Google Earth Engine to study surface water from space. He is the principal author of the Aqua Monitor algorithm and website.**

Dr. Fedor Baart **is an expert in the field integrated modelling. His goal is to make computer models data driven, interactive, visual attractive and exploratory. In his work he combines his unique academic background in technological and behavioural sciences, with his outstanding knowledge in information sciences and database technology. In his role as software architect and developer at Deltares, he plays a key role at Deltares in the development of information systems and user interfaces based on the latest technology.**

H.C. (Hessel) Winsemius, **received his PhD, Cum Laude, at the the Delft, University of Technology His research was aimed at the use of large-scale satellite observations, in particular of the gravity field and evaporation processes, as complementary data for the construction and calibration of hydrological models. Since 2009 he has been at Deltares where he acquired skills in working in developing countries and cooperating with governmental institutes. Hessel Winsemius has been active in several courses of the chair of Hydrology at the Delft, University of Technology. Currently he is also part-time researcher at the Faculty of earth and Life Sciences of the Vrije Universiteit Amsterdam**

Jaap Kwadijk **received his PhD from Utrecht University in 1993. Since 1997 he has been at Deltares (WL|delft-hydraulics). His expertise is climate change, flood and water management and worked on these issues in Europe, Iran, Hong Kong, Mongolia, Bangla Desh and Egypt, where he lived for two years. He was one of the founders of the Deflt-FEWS forecasting system, one of the most widely used forecasting systems in the world. Currently he is Director of Science of Deltares. Since 2012 he is also part time professor Climate and water management at the Twente University.**

Noel Gorelick **has been a software engineer at Google for nearly 10 years, having previously worked on a number of NASA Mars Missions and the Cassini mission to Saturn. He's the author of Google Moon, Google Mars and one of the founders of the Google Earth Engine project; a platform for planetary-scale analysis of remote sensing data, dedicated to helping solve society's biggest challenges.**

Nick van de Giesen **received his Ph.D. from Cornell University, after which he was post-doc in West Africa. In 1998, he moved to the Center for Development Research (ZEF), University of Bonn, Bonn, Germany. Since 2004, he has been with the Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands, where he currently holds the "van Kuffeler" Chair of Water Resources Management. He is chairman of the Delft Global Initiative, PI of the eWaterCycle Project (http://forecast.ewatercycle.org), and co-director of the Trans-African Hydro-Meteorological Observatory (www.tahmo.org).**

the main lake suggest that the area of surface water has increased between 2000 and 2010. On the other hand, the green colours in the northwest suggest that this area is becoming dryer.

Torbjorn Tornqvist and Jaap Nienhuis from Louisiana (USA), reviewed the application of Aqua Monitor in the Mississippi delta where it nicely shows the activity of the delta and the dramatic land loss at many locations. They proposed to use Aqua Monitor to validate a new approach to predicting the delta plan-view shape based on the dominance of fluvial flow, waves, or tide-driven sediment transport at the river mouth. An initial application was made to selected river deltas. The Aqua Monitor allows for testing the method to calculate sediment transport fluxes globally for all deltas (they proposed to consider approximately 14,000 delta's).

Open Source

Deltares Aqua Monitor is open-source software because we believe that making academic results fully reproducible will help to innovate the processing of satellite data for the extraction of valuable information regarding surface water and land changes.

Aqua Monitor helps create a level playing field in the access to information needed for water resources management, since everybody who is connected to the internet has access to it. To that end we believe that Aqua Monitor reduces the information gap that often exists between different competing parties in water resources. The Deltares Aqua Monitor was developed by Gennadii Donchyts working at Deltares as part of his PhD at the TU-Delft (NL). The source code of the algorithm, as well as the website, can be accessed on GitHub: http://github.com /deltares/aqua-monitor. When applying it please refer to "Gennadii Donchyts, Fedor Baart,Hessel Winsemius, Noel Gorelick, Jaap Kwadijk & Nick van de Giesen. Nature Climate Change 6, 810–813 (2016) doi:10.1038/nclimate3111". ■

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BIO-ECOLOGICAL DRAINAGE SYSTEMS (BIOECODS)

AN ALTERNATIVE SUSTAINABLE APPROACH TO OVERCOME WATER RELATED ISSUES

BY PROF. DR. NOR AZAZI ZAKARIA, PROF. DR. AMINUDDIN AB. GHANI & IR. CHUN KIAT CHANG

Figure 1. BIOECODS as a National Pilot Project @ Engineering Campus, Universiti Sains

BIOECODS is an innovative sustainable drainage system that helps restore the natural environment, maintain river flow and control ground subsidence. BIOECODS offers an exemplary model for urban stormwater management in tropical climates. It comprises of three components, namely ecological swales, biofiltration storage (Dry Pond), and Ecological ponds (Wet Pond, Detention Pond, Constructed Wetland, Wading River and Recreational Pond).

BIOECODS: A sustainable approach to overcome water related issues

BIOECODS is designed to solve three major water-related problems commonly encountered in Malaysia which are flash floods, river pollution and water scarcity during dry periods. After the 1998 crisis, when Kuala Lumpur and Selangor experienced water scarcity issues, the Malaysian government realized the importance of sustainable water management in urban areas. Therefore, it decided that reuse of water in urban areas should be implemented. However, it is difficult to reuse the water in urban areas since only polluted water is flowing through them. According to the Department of Environment, most of the river basins in Malaysia are polluted with suspended solids because of uncontrolled urban development.

The main cause of pollution comes from effluents of the industrial sector, which contain lower dissolved oxygen, as well as ammonia released from animal farms and domestic waste. A lot of effort has been devoted to increase the quality of river water. However, the pollutant sources are still not being completely eliminated and thereby they are degrading the water quality of the rivers. Flash floods are a major problem caused by the degradation of streams. Flash floods have increased in urban areas due to reduced river hydraulic capacity as a result of sediment deposition, which causes clogging of the waterways and subsequently raises the water level leading to flooding.

Conventional drainage systems comprised of concrete drainage channels have been widely used in Malaysia. They have been designed to provide the fastest possible transport of stormwater runoff out of the catchments into the receiving water. However, these systems have led to an increase of flash flood occurrence at the downstream part of the catchments. In addition, more rivers have become polluted because of the open drainage system and thus the quality of life in many urban communities has suffered. Therefore, the conventional drainage systems are not the best solution for solving the flash flood problem in Malaysia.

BIOECODS as a National Pilot Project

There is a need to find a sustainable approach in order to mitigate the flash flood issues and to avoid the occurrence of such problems in new developed areas. In order to overcome the current flash flood problem, the Department of Irrigation and Drainage (DID) of Malaysia is embarking in a new solution of managing stormwater runoff called "control at source".

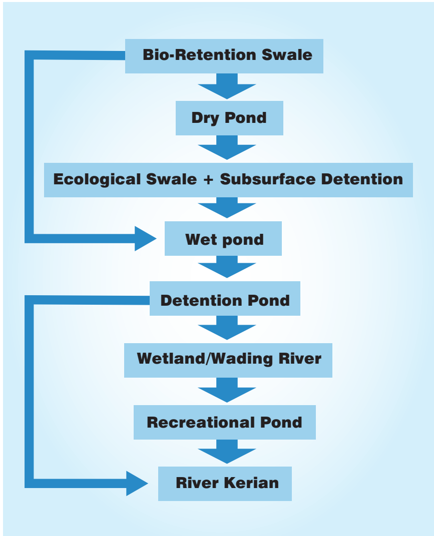

Figure 2. Schematic Diagram of BIOECODS

DID has collaborated with University Sains Malaysia (USM) to implement the Bio-Ecological Drainage System (BIOECODS) as a national pilot project at its Engineering Campus, USM which was completed by the end of the year 2002. Figure 2 shows the schematic diagram of BIOECODS.

BIOECODS Study

The research study on the capability of BIOECODS in managing stormwater runoff in the 320-acres catchment area of the Engineering Campus has been carried out since 2003. In terms of both quantity and quality, it has been proven that BIOECODS is able to minimize hydrological changes in a catchment area. In addition, contaminated

Figure 3. Ecological Swale

Figure 4. Ecological Pond (Wading River)

stormwater can be cleansed, the amenity value at USM Engineering Campus can be improved by promoting natural processes such as infiltration, flow retardation, storage and purification before discharging the treated stormwater at the downstream end of River Kerian.

The results of the study indicated that BIOECODS can be a viable and sustainable method for both water quantity management and water quality treatment in new development areas.

Conclusions

In conclusion, BIOECODS is a sustainable approach to overcome water related-problems such as flash floods, river pollution and water scarcity. This national pilot project of BIOECODS is viewed as a prototype for the development of new urban areas by implementing several components of BIOECODS that can meet the requirements of Urban Stormwater Management Manual for Malaysia (MSMA) to manage and control stormwater runoff quantitatively and qualitatively at its source.

Way Forward

BIOECODS has been successfully adopted in various places in Malaysia. One of the recent applications of BIOECODS is located at the on-going new green township development of Kwasa Damansara, which will be one of the technical visit sites during the 37th IAHR World Congress in Kuala Lumpur. BIOECODS has paved the way for a promising development in the infrastructure design for the new green township development.

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Figure 5. Visitors to BIOECODS

Prof. Dr. Nor Azazi Zakaria **has served in Universiti Sains Malaysia since 1994. He then established the River Engineering and Urban Drainage Research Centre (REDAC) in 2001 and has since remained as the Director. His main research interests are Sustainable Urban Drainage Systems and River Management. Prof. Dr. Nor Azazi is the leading researcher in the innovation of Bio-ecological Drainage System (BIOECODS), and is now an established figure in the field of stormwater management at national and international levels. He sits in the Executive Committee for Malaysian National Committee on Irrigation and Drainage (MANCID) and Malaysia Stormwater Organization (MSO), as well as IAHR APD.**

Prof. Dr. Aminuddin Ab. Ghani **is presently the Deputy Director of River Engineering and Urban Drainage Research Centre (REDAC) since 2001. His main research interests are Sediment Transport, Flood Risk Management (FRM) and Sustainable Urban Drainage Systems (SUDS). He is an exco member for Sewer System and Processes Working Group (SSPWG) under the auspices of International Water Association (IWA) and International Association for Hydro-Environment Engineering and Research (IAHR)'s Joint Committee on Urban Drainage. Presently Prof. Dr. Aminuddin is an Editorial Board Member for the International Journal of River Basin Management (JRBM), published by IAHR and an Associate Editor for the IWA's Water Science and Technology Journal.**

Ir. Chun Kiat Chang **started working at the River Engineering and Urban Drainage Research Centre (REDAC) since June 2002. He received Bachelor of Engineering (Civil Engineering) from Universiti Sains Malaysia (USM) in 2002, and Master of Science in River and Urban Drainage Management from USM in 2006. He has an experience in research and consultancy projects such as drainage improvement and flood mitigation projects, sediment transport modeling study as well as application of Sustainable Urban Drainage Systems (SUDS) and Bio-Ecological Drainage System (BIOECODS). He is member of Certified Professional in Erosion and Sediment Control (CPESC), corporate member of The Institution of Engineers Malaysia (IEM) and also the Deputy Secretary for the IAHR Malaysia Chapter.**

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Recognizing Innovation

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Creativity Prize

Creativity Prize

The Prize was shared by two teams of researchers:


Dr. Rita Colwell


Dr. Shafiqul Islam

1) Dr. Rita Colwell (University of Maryland at College Park) and Dr. Shafiqul Islam (Tufts University, USA)
for using chlorophyll information from satellite data to predict cholera outbreaks at least three to six months in advance.

2) Dr. Peter J. Webster (Georgia Institute of Technology, USA)
for applying knowledge of the effects of ocean-atmosphere interactions on monsoon strength to provide one to two-week lead time forecasts of monsoonal floods for highly populated coastal regions.


Dr. Peter J. Webster

Surface Water Prize

Surface Water Prize

Dr. Gary Parker (University of Illinois Urbana-Champaign, USA)
for contributing to our understanding of meandering rivers, the shapes they take, and how they change themselves and their floodplains as they migrate.


Dr. Gary Parker

Groundwater Prize

Groundwater Prize

Dr. Tissa H. Illangasekare (Colorado School of Mines, USA)
for improving the fundamental understanding of fluid flow and chemical transport in porous media, leading to the reliable prediction of the long-term fate of pollutants in groundwater systems.


Dr. Tissa H. Illangasekare

Alternative Water Resources Prize

Alternative Water Resources Prize

Dr. Rong Wang & Dr. Anthony G. Fane (Nanyang Technological University, Singapore)
for developing hollow fibre membranes that combine forward osmosis with a reverse osmosis (RO)-like inner selective layer and a previously undiscovered positively charged nanofiltration (NF)-like outer selective layer, which effectively reduces the effects of scaling and flux losses.


Dr. R. Wang Dr. A. G. Fane

Water Management and Protection Prize

Water Management & Protection Prize

Dr. Daniel P. Loucks (Cornell University, USA)
for the development and implementation of systems tools that provide an effective, dynamic, and successful framework for addressing practical water resources management problems worldwide.


Dr. Daniel P. Loucks

Nominations are open for the 8th Award. Nominations can be made online until 31 December 2017.

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ADVANCED FLOOD FORECASTING FOR MALAYSIA

BY NOR HISHAM MOHD. GHAZALI, EMMA BROWN, SAZALI OSMAN & WAN HAZDY AZAD

HR Wallingford is working with the Malaysian government to develop a new National Flood Forecasting and Warning System for its key river basins to help prepare for, and mitigate, the effects of future floods.

Across Malaysia, an estimated fifth of the population is at risk of flooding. Large areas of the country repeatedly suffer from prolonged, significant floods; these cause widespread disruption for communities, business and critical infrastructure, often requiring many tens of thousands of people to be evacuated from affected areas. The impact of these floods has been made worse over the past decade by rapid urban growth, as these developments have modified the rivers' flow regimes and flooding mechanisms.

A new national flood forecasting and warning system

The Malaysian Government's Department of Irrigation and Drainage (DID) provides a flood forecasting and warning service to the public. It is developing a programme based upon the phased implementation of systems, which together form a new National Flood Forecasting and Warning System (NaFFWS) for its key river basins. The NaFFWS will help them to prepare for, and mitigate, the effects of future floods, using an integrated approach via non-structural measures.

The objective of the NaFFWS is to develop and maintain an effective and efficient integrated flood forecasting and river monitoring system, with flood warning dissemination, using national network data, telemetry data, radar data and rainfall forecasts; the NaFFWS is a tool designed to enable effective decision support by DID. Ultimately, the NaFFWS will represent all of the key river basins for the whole country. In the first phase, three east coast rivers (Sg Kelantan, Sg Terengganu and Sg Pahang) have been started. The flood forecasting model developed is using Infoworks Integrated Catchment Modeling (ICM) with the support from HR Wallingford's UK and Malaysian-based experts.

The extensive experience of HR Wallingford's experts in developing similar systems for tropical river basins has been important for these projects, where climatic conditions can be challenging and lead times for flood warning can be short.

The components of the NaFFWS are fully automated systems driven by a combination of live, telemetered gauged data from DID's, spatial rainfall radar data, and Numerical Weather Prediction rainfall forecasts from the Malaysian Meteorological Department.

Continued on page 49

Figure 1. Extreme floods have caused significant damage to infrastructure in Malaysia. This bridge in Kelantan River was destroyed by the December 2014 flood

Nor Hisham Ghazali **currently heads the Water Resources and Hydrology Division at the Department of Irrigation and Drainage Malaysia. He has served the Department for 30 years mostly as a coastal engineer. Since 2008, his focus has been in water resources management and flood mitigation.**

Emma Brown **has over 20 years' international experience in hydrology and water resources management. Most recently, she led HR Wallingford's team helping to deliver the first stage of an innovative National Flood Forecasting and Warning System for the Malaysian government.**

Sazali Osman **is a Senior Principal Assistant Director in the Hydrology and Water Resources Division, Department of Irrigation and Drainage Malaysia. He currently responsible in the planning and development of new flood forecasting system called as National Flood Forecasting and Warning Programme (PRAB).**

Wan Hazdy Azad **currently works as a Senior Assistant Director in the Hydrology and Water Resources Division, Department of Irrigation and Drainage Malaysia. His specialist in 2 Dimensional Hydrodynamic Flood Plain Analysis Modelling and responsible in the planning and development of new flood forecasting system called as National Flood Forecasting and Warning Programme (PRAB).**

REDUCING ENVIRONMENTAL IMPACTS OF DREDGING THROUGH ADAPTIVE MONITORING – EXPERIENCE FROM MALAYSIA

BY JACK LEE VUN ZAC, JUAN C. SAVIOLI, C. PEDERSEN

Dredging and Its Impacts

The increasing requirement for economic growth has led to the need to modify the natural environment to accommodate developments that can contribute to this growth. An area where development has focused is the coastal zones which constitute a small percentage of the total global land mass, but has significant development potential. Rapid development in this area has meant increased construction of coastal infrastructure, such as urban development, ports, marinas, airports, oil and gas pipelines and support facilities, power plants, tourist facilities, etc.

Dredging works are often required for these types of projects to increase the nearshore water depth in order to enable larger vessels to navigate and berth at a port or jetty serving the area. Dredging without proper management can have irreversible impacts in highly sensitive environments, especially near coral reef areas and other similarly vulnerable systems. Properly designed and managed dredging works can:

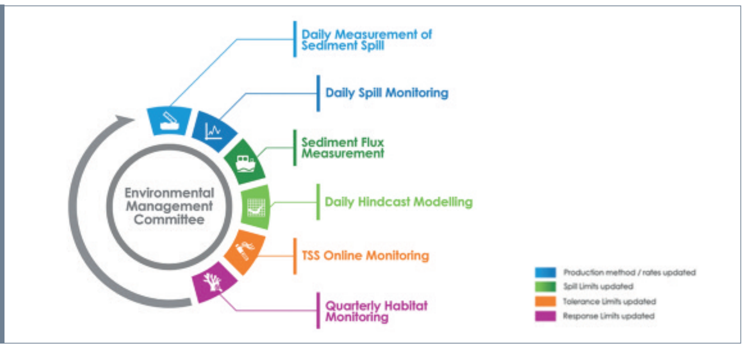
- Eliminate or minimize any irreversible impacts on sensitive receptors;
- Have only minimal temporary impacts (transient impacts to fishing grounds, aquaculture, coral reefs and/or tourist areas)
- Minimize risks of real or perceived impacts that could lead to interruption of the dredging works; and
- Enable better documentation of dredging and monitoring activities.

Environmental Impact Assessment

Before dredging works are carried out, it is a common practice to undertake an environmental impact assessment (EIA) to determine the baseline conditions, assess potential impacts and define the necessary mitigation measures. This usually includes extensive field data collection and detailed hydraulic modelling. Key potential impacts addressed in an EIA can be categorized into two groups:

- **Permanent Impacts** are induced by the proposed structures and works on currents, water levels, waves, sediment transport, water quality, shoreline evolution in and near the area, etc. These impacts last as long as the structures and works are in place;
- **Temporary Impacts** occur during construction (dredging) work and are usually related to sediment spill during dredging. The extent and potential impacts of sediment plumes generated during the dredging depend on the type of dredger, dredging methodology, type of sediments and flow conditions. These impacts are usually limited to the duration of dredging. However, if not managed properly they could become permanent.

Figure 1. Key components of a feedback EMMP



The assessment of temporary impacts is usually based on a number of assumptions which are based on best available information, but which are often uncertain at the EIA stage. Some key uncertainties at this stage include:

- Exact dredging methodology and production rates (the exact equipment is known when the contractor is appointed and has planned the work in detail);
- Timing of the works, both in terms of starting time and duration;
- Sediment properties in dredging spill – the settling properties of the sediment suspended in a passive plume in the water column as a result of dredging becomes exactly known only after commencement of dredging;
- Current flows and climatic conditions are variable and usually there are no data on their variability and seasonality;
- The spill rates depend on production rates, geotechnical and climatic conditions;
- Use of overflow environmental device (enviro valve), or other equipment in the dredger.

To account for these uncertainties, a level of "conservatism" is usually applied in the modelling in support of the EIA. However, because of these uncertainties it is not possible to assure that there will be no negative impacts on any sensitive receptors. Recognizing the uncertainties, not least among them the variable conditions at the site, it is good practice to manage dredging works based on actual observations during dredging operations to ensure that that no unforeseen impacts are realized, that the given Environmental Quality Objectives (EQO) are met, and that dredging works are carried out with minimal disruptions and within specified cost constraints. To meet these multiple objectives, DHI has developed a pro-adaptive Environmental Feedback Monitoring and Management process for dredging works which for the past two decades has been successfully applied in Europe, Malaysia, Singapore and elsewhere.

Environmental Feedback Monitoring and Management of Dredging Works

Pro-adaptive Environmental Monitoring and Management Plans (EMMP) based upon feedback monitoring principles are typically required for marine related construction activities notably those that lie within close proximity to sensitive environmental receptors, such as, coral reefs and seagrasses. This approach was initiated and developed by DHI in Denmark in the 1990's for the Øresund road-rail link between Denmark and Sweden (Doorn-Groen, 2007). Since then, the successful technique has been refined and implemented in Singapore (Pasir Panjang Terminal Expansion), Indonesia (Turtle Island, Bali), Brunei (Pulau Muara Besar) and Malaysia (Sapangar Port, Teluk Rubiah, and Pengerang Terminal). Some of these projects are described in the Central Dredging Association (CEDA)'s position paper (2015) on adaptive monitoring.

Proactive EMMP is implemented during the dredging works, so that potential impacts can be more readily and accurately identified and mitigated as the project progresses. The principles upon which this approach is based are:
- Working-with-nature approach;
- Operational forecast and online monitoring of key environmental parameters;
- Predicting and preventing potential impacts by an adaptive management program.

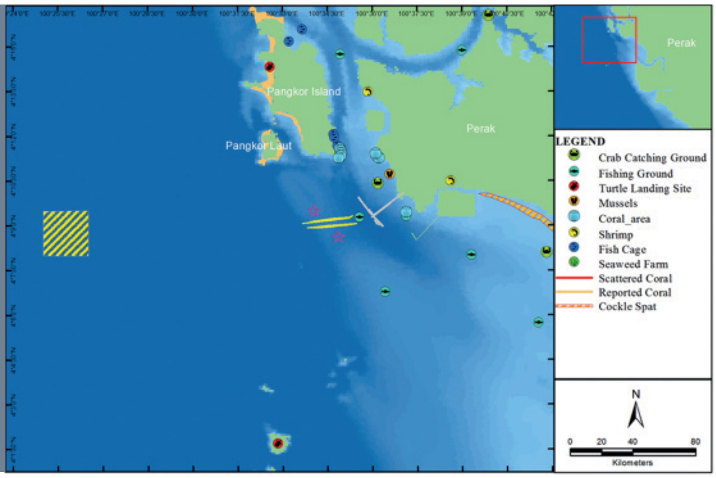
While traditional non-feedback EMMPs are reactive and dependent on coarse spatial and temporal field data monitoring, feedback EMMP utilizes the combination of detailed numerical hindcast and forecast sediment plume models and intensive field data monitoring. The main components of the feedback EMMP include the following:
- Environmental baseline data collection;
- Determination of environmental tolerance limits for the key environmental receptors;
- Assessment and update of work plans specifying the distribution of dredging works;
- Specification of sediment spill budget for the associated dredging works;
- Compliance monitoring (daily basis) against the pre-determined sediment spill budget limit;
- Control monitoring of real time measurements and comparison to response limits, such as online turbidity data or weekly sedimentation data;
- Sediment spill hindcast modelling (daily basis) which assesses the impacts arising from the actual dredging works and hydraulic conditions;
- Habitat monitoring (quarterly basis) of key sensitive biological receptors such as coral reefs, seagrasses, etc.

As such, feedback EMMP provides the level of responsiveness and documentation necessary to assure both authorities and other stakeholders that the works meet the EQOs throughout the construction period.

EMMP Case Study – Teluk Rubiah, Malaysia

A feedback EMMP was successfully applied in Malaysia for the dredging works at the proposed iron ore terminal developed by Vale Malaysia Minerals Sdn Bhd at Teluk Rubiah, Perak, Malaysia. The USD 1.4 billion project includes the development of an iron ore distribution centre, a 1.8 km deep water jetty receiving shipments of iron ore from Brazil and exporting blended iron ore as well as pellets, and a dredged channel for access to the jetty. Standard dredging mitigation measures were inadequate due to complex site conditions in the area, including sensitive environmental habitats, fishing grounds, aquaculture farms, and tourist resorts. The client needed a comprehensive and reactive EMMP to keep the dredging impacts to a minimum while ensuring that the targeted construction schedule and budget were achieved.

Figure 2. Site location for Vale iron ore terminal at Teluk Rubiah, Malaysia. The yellow lines refer to the dredged channel; grey lines refer to the jetty; yellow box refers to the disposal site



A combined monitoring approach was applied at the project site to carefully manage the expected sediment spills during dredging to ensure that set tolerances for environmental receptors were not exceeded. This was achieved through a spill control and feedback monitoring with the following processes:
1. Application of a daily spill budget approach;
2. Modelling based on DHI's MIKE 21 MT (mud transport model) throughout the dredge period to ensure that the spill budget is adhered to and the EQOs are met. The sediment transport model describes the transport of the sediment spill to evaluate the location of the sediment plume both in space and time. The model was revalidated against measured data to ensure that the predictions are as accurate as possible;
3. Continuous real time measurements and monitoring works;
4. Adoption of mitigation measures if required to achieve the environmental objectives.

Dredging Spill Limit

The spill limit developed during the EIA was re-assessed before the start of dredging works. This was done based on more detailed information provided by the dredging contractor and a value was defined as a starting spill limit for the dredging period during the Northeast monsoon. Adjustments to this spill limit value were re-assessed during the dredging period as part of the adaptive management programme.

Plume Monitoring & Management

A comprehensive monitoring campaign was implemented that included:
- Monitoring of overflow to calculate the spill;
- Hindcast modelling of all dredging operations based on actual dredging records. This

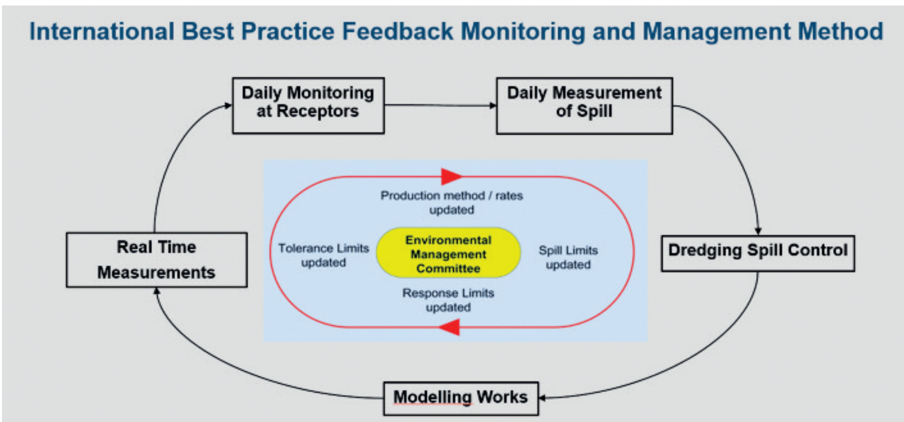


Figure 3. Feedback monitoring approach applied for the Teluk Rubiah project

- provided a detailed image of the sediment plume both in space and time;
- Daily water sampling at fixed stations;
- Online Acoustic Doppler Current Profiler (ADCP) measurements at two locations to derive Total Suspended Solids (TSS) levels and current flow conditions; and
- Current and TSS transects at three stages of the project to produce details of the spatial extent of the sediment plume for model calibration;

Trigger Levels

Three trigger levels based on TSS concentrations were defined for the project:

- Level 1 based on a daily "spike" exceedance occurs;
- Level 2 based on the analysis of 3-day running average values;
- Level 3 based on 7 or 14-day running average values.

Level 1 was unlikely to cause any impacts and no immediate action was required. These events were, however, analysed to avoid any further issues and close attention was paid to sediment spill rates on subsequent days. For Level 2 cases, the exceedance had to be investigated based on results from the monitoring and modelling works and mitigation measures had to be implemented to ensure that levels were brought back under the limit. Lastly, Level 3 indicated a long term violation of the trigger values and immediate actions were required. The trigger levels were defined at the start of the feedback monitoring programme based on collected data and published information for:

- Sediment spill – The three levels were defined based on duration as a daily spike, 3-day running average exceeds the spill limit and 14-day running average exceeds the spill limit;
- Modelling – Three levels were also defined based on duration e.g. excess of TSS > 5 mg/l for more than 10% of the time for daily, 3-day and 14-day running periods;
- Monitored data – Measured data do not distinguish between background and dredged derived concentrations, but they are important to verify the models and effects that are not resolved by the model. The trigger levels defined based on the type of receptor and the conditions at the site "clear" and "turbid water" were based on baseline data with different trigger values. These values are assessed on a daily, 3-day and 7 day running period.

Analysis

The dredging works were monitored continuously based on daily records. This information was provided by the dredging contractor and included the location of the dredger in time and its operational status (dredging, travel time, disposal, etc.). This information together with overflow sampling was used to carry out modelling and in conjunction with the daily spill records, daily monitoring data at sensitive receptors. The online TSS measurements provided a detailed picture, both in space and time, of the on-site conditions. Based on this information the environmental team evaluated the conditions on daily basis to determine if any violation occurred and, if necessary, define mitigation measures.

Close interaction between the dredging contractor and the environmental team allowed having discussions on the best approaches that would minimize impacts, especially in the northern area, where the most sensitive receptors were located. One of the mitigation actions implemented was that of only allowing turbid water from the dredger's hopper to be "overflowed" into the sea when currents were southward. This way the generated sediment plume was directed southward, away from the most sensitive receptors. A comparison of dredging with controlled and not controlled spill is shown in Figure 4. As can be observed in Figure 4, in controlled operations the TSS levels in the sensitive areas are reduced.

Another implemented mitigation measure was to concentrate the overflow from the hopper along the outer offshore dredging areas so that the plume moves away from the sensitive receptors This was only practical at the initial stages of the project when the dredging area included the overall channel. However, in later stages, when the dredging had to focus on particular sectors of the channel, this option was not viable.

During the dredging the communication between the dredging contractor and the environmental team was extremely important as mitigation measures had to take into consideration operational conditions. In particular conditions an increase in dredging rates was required for a short period for operational reasons. When this occurred the sediment spill impact was closely followed, particularly at the identified sensitive receptors based both on monitoring data and modelling results.
Modelling was extremely important in the analysis as it provided a link between the dredging and the monitoring data. In one case, an exceedance was observed at one particular station and the hindcast modelling confirmed that this was caused by the dredging due to a combination of high spill rates and overflowing from one of the trips at the eastern end of the

Jack Lee Vun Zac **is a Senior Coastal Engineer and Project Manager at DHI Malaysia. He is a graduate from the University Southampton (MSc. Engineering in the Coastal Environment) and Curtin University of Technology (B. Eng. Civil and Construction). Since joining DHI in 2010, he has accumulated extensive skills and experiences in project management and the applications of coastal numerical modelling, field survey, coastal structure design, data analyses, and handling technical training courses.**

Juan C Savioli **is head of the Coastal and Marine Department, DHI Malaysia. Juan has over 25 years of experience in coastal and marine engineering. He has lead DHI's Kuala Lumpur coastal and marine modelling team for over 10 years where he participated in a large range of projects both in Malaysia and internationally. The scopes of projects vary from dredging and reclamation works to shoreline management studies and hydraulic and environmental assessment as well as vulnerability assessment and adaptation for climate change.**

Claus Pedersen **is Technical Director at DHI Malaysia. He graduated with a Ph.D. from Technical University of Denmark in 1993. Major areas of expertise concern coastal processes and morphology. Since his posting to DHI (Malaysia) in 1999, his area of responsibility and experience has extended to include the entire range of DHI's marine modelling services. Dr. Pedersen has been a key figure in numerous studies in Malaysia and the region and has extensive experience on large dredging and reclamation projects.**

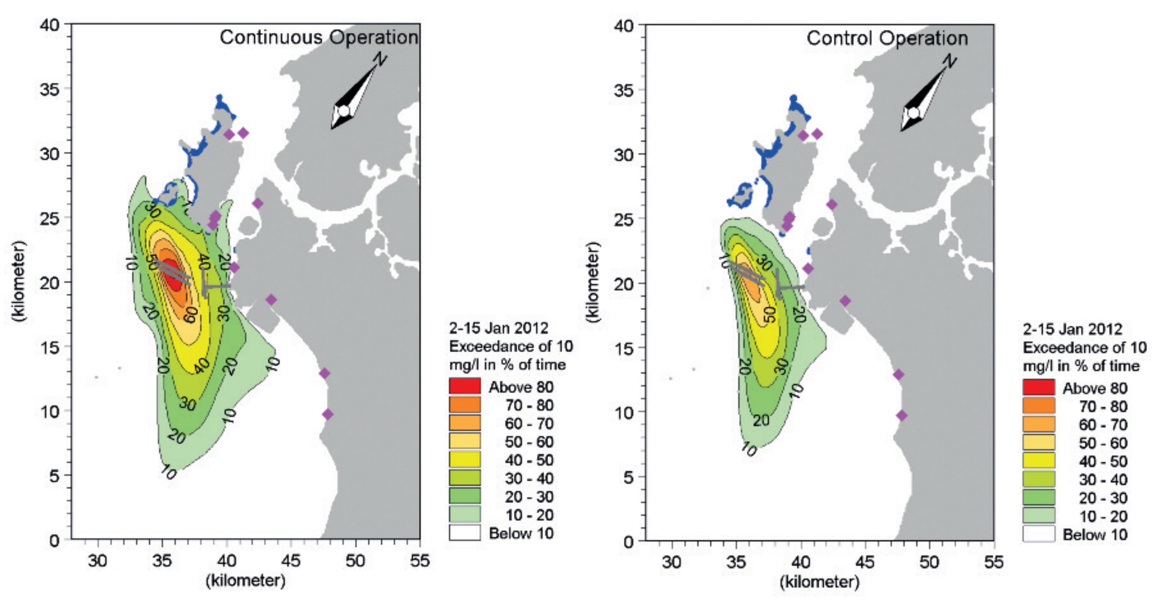


Figure 4. Predicted TSS 10 mg/l level exceedence for continuous (left) and control (right) dredging operations

channel just during flow reversal. This was discussed with the dredging contractor and corrective measures were taken to reduce TSS levels at the sensitive receptor area.
As part of the EMMP there was also close communication between the environmental team and the regulatory authorities. Fortnightly environmental reports were issued and visits to the dredger were organized to brief the authorities on the status of the dredging and the procedures that were in place. A very positive feedback was obtained from these discussions.

Conclusions

The implementation of a feedback EMMP programme can be very beneficial during dredging operations as it provides a detailed assessment of the dredging works and their possible impact on sensitive receptors. This allows for optimization of the dredging operations – both in terms of cost and time – while minimizing impacts on the receptors. In addition, it ensures the authorities that the works are in compliance with what was proposed during the EIA.

The application of this methodology in the Teluk Rubiah, Malaysia has proven to be highly successful as it allowed to handle the uncertainties of the assumptions made in the early stages of the project and produced accurate predictions that enabled the environmental team and the dredging contractor to manage the dredging works with minimal impacts. Through the understanding of the hydraulic and environmental conditions of the dredging area, the critical components from nature that could potentially impact the environment were identified, which allowed for a more efficient approach than the standard mitigation measures that would have added 50% to the cost of the project. Critical to the client, apart from completing the dredging without any environmental breach, was also the fact that the project was completed ahead of schedule at much lower cost than initially calculated. The dialogue between the environmental team, dredging contractor, and the authorities was vital in achieving this successful outcome.

Acknowledgement

We would like to thank Vale Malaysia Minerals Sdn Bhd for permission to publish the case study of the Teluk Rubiah project. ■

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Typically, automatic hourly simulations are carried out to forecast water levels and flows in the river channels, and to map the flood inundation process within the flood plains. Hydrological rainfall-runoff models represent the upper catchments, running in continuous simulation mode in order to keep their internal states updated and representative of current conditions. These feed the boundaries of 1D and 2D hydrodynamic models, which model the flows in the river channels, and simulate the movement of water in the flood plains. The results are used to inform and warn DID staff, so they can take immediate action to provide an effective and proactive warning and dissemination response. Results are also passed to DID flood warning web pages, and to dedicated smartphone applications, enabling forecasts to be disseminated more widely. A parallel analytical modelling network, based upon simple but reliable methods such as regression techniques, can take over the forecasting role should the primary systems fail, forecasting water levels at a number of key forecast points around the catchment.

Ongoing structural measures for flood mitigation are captured through a flexible modelling approach that can incorporate model updates to reflect real changes in the catchments, complementing the structural measures being implemented by DID and ensuring a sustainable flood warning solution with long term benefits. ■

THE RIVER EXPERIMENT CENTRE ANDONG – A UNIQUE NEAR PROTOTYPE OUTDOOR FLUME FACILITY

BY DU-HAN LEE, HONG-KOO YEO, YONG-UK RYU & ELLIS PENNING

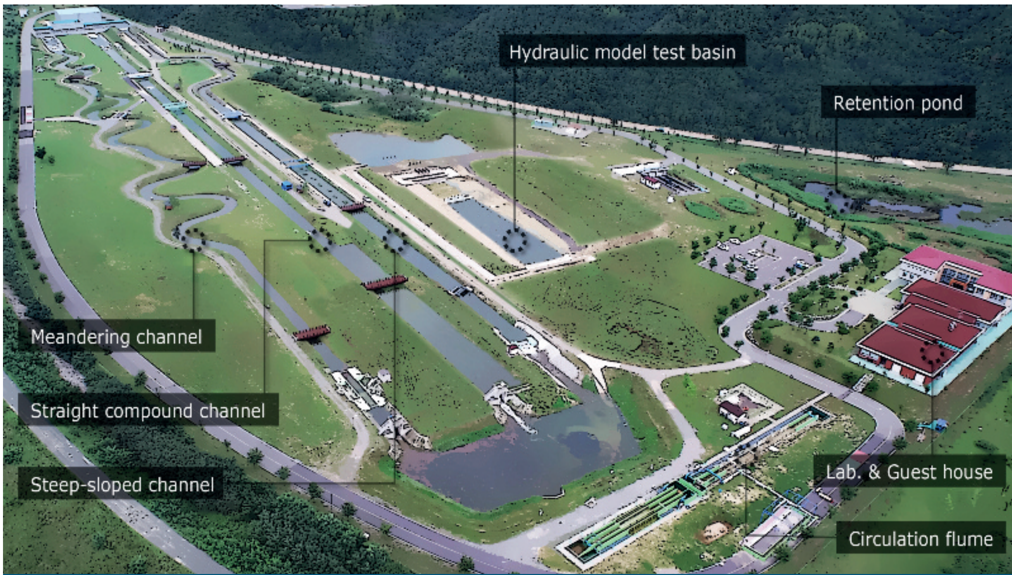


Figure 1. Overview of the REC

Recognizing the importance of improving our knowledge about the complex interactions between hydrologic regime, geomorphic evolution of river channels and the associated interactions with vegetation and biologic responses combined with the difficulties of scaling many riverine processes down to the laboratory scale, the Korean Institute of Civil Engineering and Building Technology (KICT, see textbox) has developed one of the largest river experimentation facilities in the world, the River Experiment Center (REC), in Andong. The REC has a total area of 200,000 m^2 and was designed for full scale tests with three prototype channels (600 m long and 11 m wide) and a large capacity pump facility with a controllable flow rate up to 10 m^3/s and a flow velocity up to 5 m/s. Additionally, a 100 m long and 30 m wide hydraulic model test basin and a retention pond are also part of the premises equipped for various kinds and scales of river experiments.

The River Experiment Centre was constructed in 2009 and officially opened in 2012. From then on, a large variety of experiments has been undertaken, ranging from full size tests on bank erosion prevention measures to the validation and calibration of advanced flow measurement equipment. Being outdoor, with clean waters from the Nakdong River and with a natural bed, the REC provides excellent opportunities to carry out real scale tests on vegetated flows, with naturally rooted vegetation. Also, experiments on fish behavior have been carried out. As a result, the REC fits the position between indoor smaller scaled lab and real field conditions, with the advantage that despite being outdoor, flow and water levels can be controlled and the bed level is perfectly known.

Facilities

The main facilities of the REC are three prototype channels that were designed to be able to study a wide range of stream characteristics. Four pumps with a large capacity generate a maximum flow rate of 10 m^3/s in the channels. Channel 1 has a steep section with sharp bends (slope of 1:80) to create supercritical flows for stability studies under extreme conditions. The steep section with a high flow rate generates a strong flow that is necessary for stability tests of structures such as levees, weirs and revetments. The sharp bends also allow a consideration of oblique flow direction. After the steep section, the channel has an almost flat section (slope of 1:1000) with a sandy bed. Channel 2 is a straight channel with a compound section, which allows for studies representing river-floodplain interaction. The one-sided floodplain section is located in the 150 m long downstream region of the channel. The base width of the floodplain is 6.5 times greater than the bed width of the main channel. Channel 3 is a meandering channel with various sinuosities to represent different river energy dynamics and better study flows through these bends. The meandering section is composed of 4 different sinuosities over a 400 m long region. After the meandering section, a two-sided compound section with equal berm width is located downstream. Along the channels, crossing instrumentation carriages moving over rails are equipped for accurate measurements. Besides the prototype channels, the hydraulic model test basin was designed for hydraulic model tests. Separately from the channels, the flume circulates water with its own pump system with a maximum flow rate of 2 m^3/s. The flume is filled with sand for movable bed tests as well as for other model tests. The retention pond covers an area of 17,000 m^2 and is capable of storing 15,000 m^3 of water for environmental and ecological studies in stagnant waters.

Figure 3. Members of Andong River Experiment Forum

KICT is a government-sponsored research institute responsible for establishing government policies and performing R&D on infrastructure, buildings, water management and environmental engineering for the nation (www.kict.re.kr)

Figure 2. Experiments in the REC: (a) Safety test against strong flows (b) Flows over vegetated patches (c) Bank erosion mats (d) Flows along the meandering section

Sharing knowledge at the REC – The Andong River Experiment Forum

The vision of KICT is to develop the REC into a global hub for ecohydraulics experiments where engineers and scientists from around the world can address some of the grand challenges associated with managing the world's rivers. The REC seeks to facilitate the collaborative exploration of the complex interactions among flow, sediment, geomorphology and flora and fauna at a large scale. An important part of the philosophy underlying the development of this facility has been fostering networking and collaborative research activities, with particular encouragement for young professionals. The Andong River Experiment Forum is one of the activities for achieving this goal, where experiences from around the world can be shared with a goal of collectively accelerating knowledge discovery.

The Andong River Experiment Forum aims to provide river experts all around the world with a forum for regular-basis meetings, discussions, and training on experimental approaches of fluvial and aquatic hydraulics based at the REC. The Forum mainly pursues research discussions on experimental work conducted in either the REC, or elsewhere. The Forum is open to all scientists and engineers who work on river-based studies and encourages them to join its activities. Topics include river restoration, river hydraulics, fluvial geomorphology and eco-hydraulics. Special attention is given to emerging technologies that can be used to predict and evaluate alternative future conditions using hybrid analytical approaches that integrate field observations with large-scale laboratory experiments and computer simulations.

The 1st Andong River Experiment Forum (AREF) under the theme of "Current River and Ecology Hydraulics based on Experiments" was held at the REC on April 29, 2014. In the forum, the co-chairs (Dr. Peter Goodwin, Dr. Hong-Koo Yeo) and international specialists from the U.S. (Dr. Marian Muste), Canada (Dr. Ana Maria da Silva), the Netherlands (Dr. Ellis Penning) as well as Korea (Dr. Won Kim, Dr. Dongsu Kim, Dr. Chang-lae Jang) presented various studies and discussed future directions for the Forum. In the first forum, two topics were selected for further international cooperation projects: 1) performance of instrumentation and measurement accuracy, 2) vegetated flows. These items closely connect with the discussion on using inter-laboratory comparison tests for documenting the uncertainty related to site conditions. In the 2nd forum in 2015, various studies under the topics carried out in the REC since the 1st forum were presented. Besides the performed studies, new research items that are expected to extract meaningful outcomes from large scale and natural conditions were suggested and discussed for feasible future studies. In River Flows 2016 in Saint Louis, a special session was organized for introduction of the themes and studies under the forum as well as to present the REC as a unique facility to researchers over the world. We invite those interested to join the AREF2017 which will be organized by KICT on 16-17 October 2017 in South Korea. During this year's forum we will specifically focus on the role of the REC in the validation of new monitoring techniques and sensor calibration in unscaled yet controlled situations. For more information, please contact Yong-Uk Ryu at yuryu@kict.re.kr ■

Du-Han Lee **is the head of the REC, KICT. He received a Ph.D. in Civil and Environmental Engineering from Seoul National University. He specializes in physical and numerical modeling of river hydraulics.**

Hong-Koo Yeo **is the director of the REC, KICT. He received a Ph.D. in Civil and Environmental Engineering from Seoul National University. He leads a group working for conducting hydraulic model tests in river engineering and providing technical supports for government policies. He is currently one of chairs of Andong River Experiment Forum.**

Yong-Uk Ryu **is a senior researcher at the REC. He received his Ph.D. from Texas A&M University. He specializes in physical modeling of river hydraulics and wave mechanics. He is now involved in a cooperation project with Deltares on flow-vegetation interaction.**

Ellis Penning **is a senior ecologist at Deltares and co-chairs the International Steering Committee of the REC and the Andong River Experiment Forum. She specializes in ecohydraulics with a focus on the interaction between aquatic vegetation and hydro-morphodynamics and its application in daily water management. At Deltares she leads the research programme on Nature Based Flood Defences.**

GENDER EQUITY EFFORTS IN IAHR

BY SILKE WIEPRECHT

Gender equality is a human right and means that that everyone should receive equal treatment and not be discriminated against based on their gender [1]. United Nations Universal Declaration of Human Rights states: "Mainstreaming a gender perspective is the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality." [2]

IAHR still has some efforts to undertake to achieve the aim of gender equity within the organisation. The council expressed concerns about the lack of women in IAHR leadership roles, which led to the creation of a Task Force consisting of Sharon Nunes (Vice President for Research, IBM, USA), Jing Peng (Director, Division of International Cooperation, IWHR, China), Ioana Popescu (Associate Professor of Hydroinformatics, UNESCO IHE, The Netherlands), Ana Maria da Silva (Professor, Department of Civil Engineering, Queens University, Canada) and as Chair of the Task Force Silke Wieprecht (Professor, Institute for Modeling Hydraulic and Environmental Systems, University of Stuttgart, Germany). The aim was to analyze the demographics in IAHR and develop recommendations on how to ensure that the full intellectual capacity of the water profession will be represented in IAHR membership and leadership in the future.

Actual situation in IAHR

The membership database was provided by the IAHR head office (status 8/2016). Actually IAHR at that time had 4108 members, including 2506 males, 616 females and 986 whose gender was unknown. The group of "unknown" is quite high and could distort the analysis. Thus, in the following graphs this group is not considered (Figure 1).

Silke Wieprecht **is a full-time professor and the head of the Department of Hydraulic Engineering and Water Resources Management of the University of Stuttgart. She is advisor of the Baden-Württemberg Young Professional Network of the IAHR, and member of the World Council of the IAHR.**

There are 154 members in committees and leadership teams, including 18 females and 136 males. 61 members are active in regional divisions, including 9 females and 52 males. 19 members are in the council of which 2 are females and 17 are males (Figure 2).

The age groups are represented almost equally: 34 % are under 35, 30% are in the age between 35 and 50, and 36 % are older than 50. Although there is a consistent age distribution the share of females in the age groups is very different. 30% of the members in the typical YPN-age are females, in the group of 35 to 50 the ratio of females reduces to 25 % and in the group of 50 years and older it is only 6%.

The decline of number of females is even more obvious when we look at the leadership positions. The overall share of women in IAHR membership is approximately 20%. As members of technical committees women are 12 % and in regional divisions 15 %. However, in the council there are only 2 % women.

Comparison with other institutions

Several publications and statistics can be found documenting more or less the same tendencies for STEM disciplines and for engineering in particular. DeCohen and Deterding (2009) [3] report that of the university students enrolled in engineering disciplines approximately 22 % are female and among the graduates 24 % are female. This means that the retention rate of females is higher compared to male students. However, the higher we climb the job ladder the more we are losing the young women.

Applying the published data from the National Science Foundation on the US Science and Engineering Workforce Trends and Composition we see how much (or little) women's involvement in STEM fields has changed over the course of 17 years between 1993 and 2010. The results of this study include men and women ages 16 and over pursuing studies or working in a STEM field. The male to female ratio has remained almost constant at 70:30, despite the time passed (Figure 3).

Typical drawbacks for women

Analyzing the literature, own experiences, and personal discussions with women in respective positions several typical drawbacks can be identified:

- **The struggle to break gender stereotypes:** There are many gender stereotypes surrounding everyone every day. Knowing that STEM disciplines are predominantly occupied by males, it is difficult for a female to start a career or even to be interested in STEM, or leadership positions. These stereotypes play a major role in a female's career choice.
- **Lack of female (and male) mentors:** Another barrier to females in STEM and leadership is the lack of a person they can go to for advice in a male-dominated environment. With the trend of STEM disciplines being surrounded with more men than women, it is difficult for a woman to fit in or even articulate their opinions.
- **Flexibility in the job:** Missing flexibility is a concern in some job positions. This is in a certain way also applicable to IAHR. Although, IAHR does not offer job positions for its members, it offers leadership positions and responsibilities. This represents the area where IAHR could be different from other organizations in being more flexible.

Potential measures to be taken in IAHR

Gender equity also requires an examination of organizational practices and policies that may

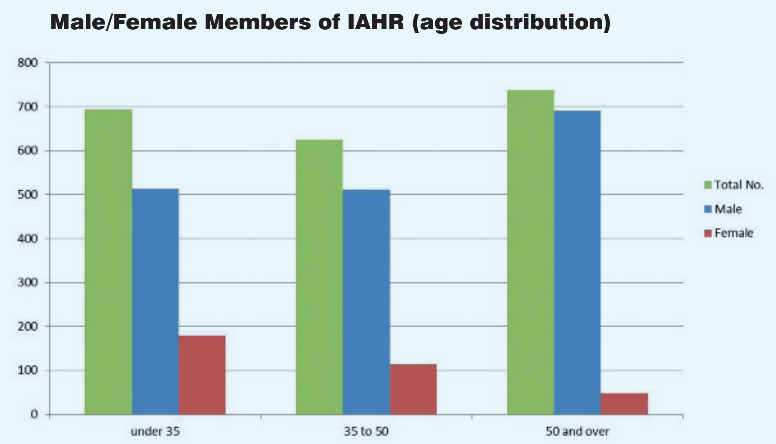


Figure 1. Absolute numbers of male and female members in IAHR distributed to the different age groups of under 35 (YPN), 35 to 50 as well as 50 and over

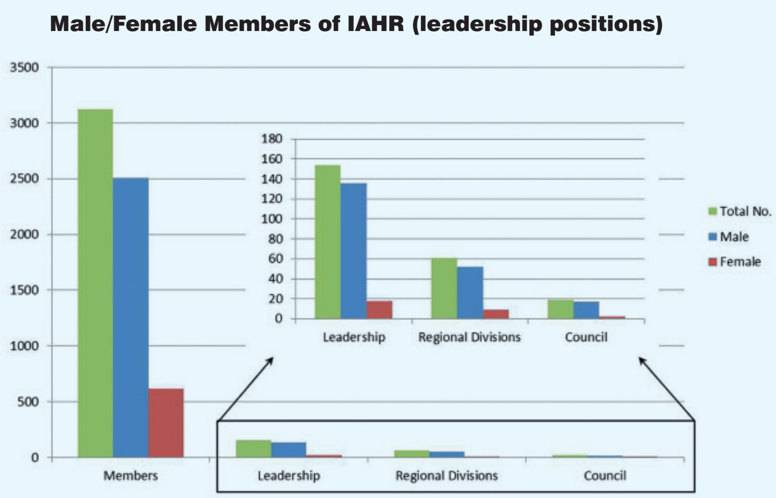


Figure 2. Absolute numbers of male and female members in IAHR distributed to the different positions of all members, leadership positions (e.g. technical committees), members in regional divisions as well as council members

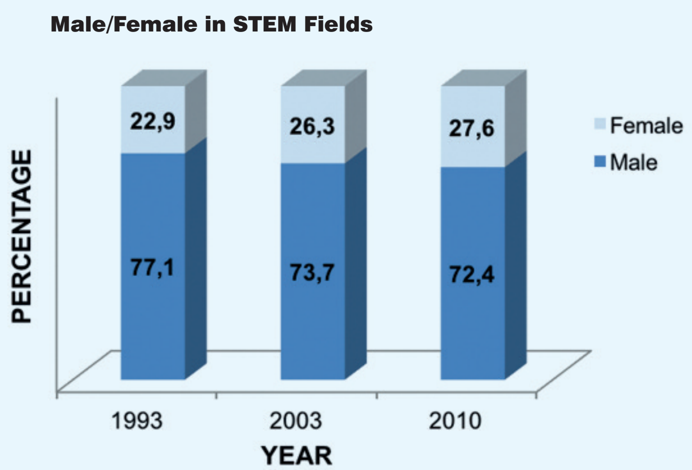


Figure 3. Percentage of women in STEM fields (Data from US S&E Workforce: Trends and Composition from National Science Foundation)

hinder the participation and development of women. Therefore ideas for potential measures are identified:

- **Awareness and importance of the topic:** It is important that we set up, enhance, revive and exemplify within IAHR a culture which breaks the gender stereotypes and mitigates their past effects. This means that gender equity is not an issue only for women. It is in fact an issue for the entire IAHR community. It is a serious and important topic and nobody should smile at it. It is also not a "nice-to-have", or an inconvenient duty. In fact, it is a basic requirement for a well-functioning, diverse and emancipated association.
- **Mentoring:** We are a male-dominated association. There is only a restricted number of females in leadership positions. Consequently, it is obvious that not only the women in IAHR can take over mentorship positions. It is a task for the whole community having mentors in a male-dominated workplace, who support females to work towards their interest in STEM fields and leadership positions.

Conclusion

Gender equality will be achieved only when women and men enjoy the same opportunities, rights and obligations in all spheres of life. This means sharing equally in the distribution of power and influence, and having equal opportunities and realizing their personal ambitions.

IAHR has committed itself to contribute to gender equity within the organization. Hence, it is essential to develop a common understanding that this topic is important for both, men and women. We want to provide an environment which supports women and men to step up and take ownership of this topic.

Especially, the young-age group, as the future generation of the association, can considerably contribute. The activities of the Young Professional Network (YPN) show the first successful results like increasing number of memberships. Quantity-wise this is also the age group with the highest share of females. Thus, it is very important to encourage them to stay loyal to IAHR when they proceed from the YPN status to "full" members. ■

References

[1] United Nations. Report of the Economic and Social Council for 1997. A/52/3.18 September 1997,

[2] United Nations "Universal Declaration of Human Rights" (PDF). wwda.org December 16, 1948. Retrieved October 31, 2016.

[3] De Cohen and Deterding, 2009. Widening the net: national estimates of gender disparities in Engineering, ASEE. Journal of Engineering Education, July 2009

W.A.T.E.R.: AN IAHR-EMI EVENT DEDICATED TO THE LEARNING OF ADVANCED MEASUREMENT TECHNIQUES

BY MARGARET CHEN, RUI ALEIXO, RUI FERREIRA & MÁRIO FRANCA

The Experimental Methods and Instrumentation committee (EMI) promotes several initiatives, targeting different audiences, to advance the use of experimental techniques in hydraulics research. The first Workshop on Advanced measurement Techniques and Experimental Research (W.A.T.E.R.), was premiered by the EMI and it gave PhD students, young researchers and technicians the opportunity to learn about state-of-the-art instrumentation and measurement techniques. The first edition took place between 1st and 5th August 2016 at the Flanders Marine Institute in Oostende, Belgium.

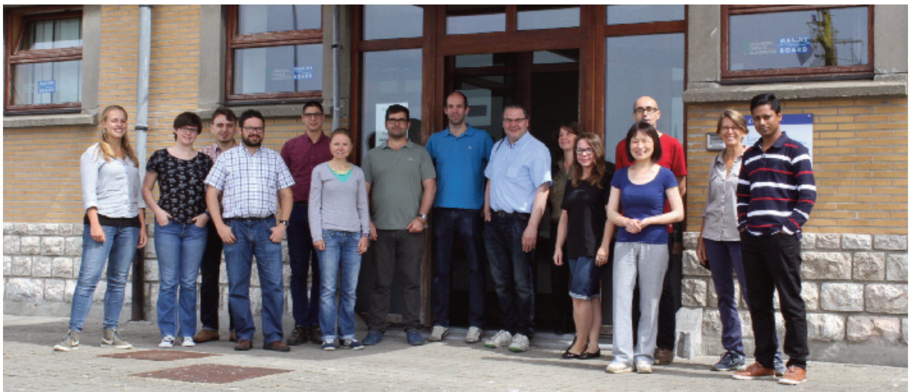


Figure 1. W.A.T.E.R. group photo in front of the Flanders Marine Institute (photo by Flanders Marine Institute)

It is essential for young researchers to learn and get acquainted with state-of-the-art measurement techniques. Such opportunity is rare. Hence, the IAHR-EMI Leadership Team proposed the organization of a new event where training in state-of-the-art instrumentation and measurement techniques could be offered to the participants. The Leadership Team members who participated actively in the organization and the development of the teaching material of the event are: Margaret Chen (Hydrology and Hydraulic Engineering department – Vrije Universiteit Brussel); Rui Aleixo (EMI chair and GHT Photonics); Rui Ferreira (Instituto Superior Técnico, Universidade de Lisboa); Mário Franca (Laboratoire de Constructions Hydrauliques – Ecole polytechnique fédérale de Lausanne). To increase the W.A.T.E.R. scope and technical level, other lecturers for specific topics were invited: Tine Missiaen from University of Ghent and Vera Van Lancker from Royal Belgium Institute of Natural Sciences.

In W.A.T.E.R., topics related to the fundamentals of hydraulic measurements were covered. These included working principles of image analysis methods with emphasis on particle image velocimetry and particle tracking velocimetry (PIV and PTV respectively); basics of acoustic Doppler velocimetry; measurement of sediment concentration and fluxes; bottom profiling and bed topography (including conductivity, temperature and depth (CTD) measurements); principles regarding the reproduction of fluvial geomorphology processes in the laboratory; and data post-processing and visualization. Laboratory setups where the measurement techniques were demonstrated and applied, and field measurements made on board of the Research Vessel (RV) Simon Stevin, were also part of the hands-on approach of the W.A.T.E.R. summer school. The manufacturer I.L.A. GmbH provided a PIV system for use and demonstration during the W.A.T.E.R. Summer School. Frank Michaux,

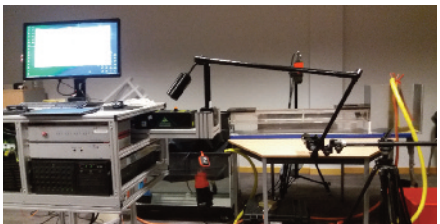


Figure 2. PIV setup (courtesy of ILA GmbH)

Figure 3. W.A.T.E.R. on board of the research vessel Simon Stevin (photo by Flanders Marine Institute)

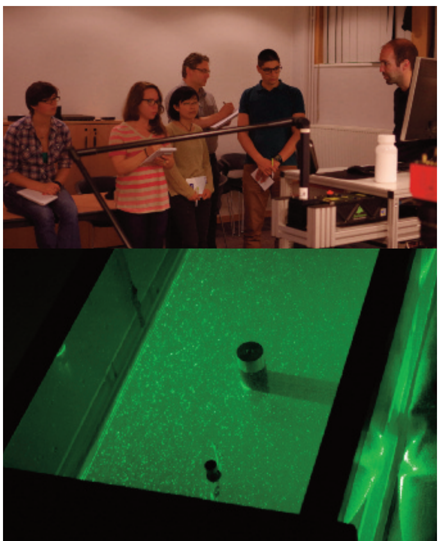


Figure 4. Laboratory sessions and PIV measurements of low Reynolds flow around a cylinder

Figure 5. Session of data processing and discussion of results

Figure 6. W.A.T.E.R. social events

from I.L.A. GmbH, was present during the workshop, providing a fully operational PIV system and support for PIV measurements.

The first edition attracted PhD students and young researchers mainly from Europe and Asia. In total six countries were represented. For the laboratory sessions, the students were divided into four groups. They were given assignments with different measuring tasks to perform. The students learned to acquire data in practice and to solve both theoretical questions and practical issues. On the final day, for the evaluation, each group presented its results in front of the class, and answered questions asked by the lecturers and colleagues. The following lively discussion took place in an open and creative atmosphere. The W.A.T.E.R. summer school counted for three ECTS credits (ECTS: European Credit Transfer and accumulation System).

Besides the training it offered, this event allowed young researchers and PhD students to interact with experienced researchers in an informal and open atmosphere. Social activities were organized every night which facilitated professional exchange, as well as bonding between the young researchers. A successful and exciting event was the "cooking night", where each group was challenged to prepare a dish for a common dinner.

The feedback received from this first event was highly positive and encouraging. A second edition is now being organized by the same team. It will take place again in Oostende in October 2017. ■

The W.A.T.E.R. summer school website is: https://watersummerschool. wordpress.com/

Margaret Chen is Professor of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel. Her expertise is associated with both in-situ experiment and model simulation of integrated multi-scale hydrodynamics, morphodynamics, and sediment dynamics linked to climate variability and flood defense; hydraulic and structure-process interaction in particular linked to port and harbor development; and physical processes including wind, wave and tide related to coastal safety. She is the promoter for several ongoing estuarine and coastal research projects involving both modeling and monitoring sand banks, beach nourishment and dune-beach-shoreface system. She is a member of the leadership team of the Experimental Methods and Instrumentation Committee of IAHR.

Rui Ferreira is Associate Professor of Instituto Superior Técnico, Universidade de Lisboa and a CERIS senior researcher. For the past 20 years, he has been involved in experimental research in fluvial, estuarine and coastal processes, development of laboratory instrumentation and mathematical modelling of free-surface flows, including the coordination of the development of PIV and bedload measuring systems and of mathematical modelling tools such as STAV model (http://www.fluidmechenv.tk/). He is Associate Editor of two international journals and has participated in the organization of several scientific events, including River Flow 2006. He is a member of the leadership teams of the Fluvial Hydraulics Committee and of the Experimental Methods and Instrumentation Committee of IAHR.

Rui Aleixo has a PhD in Engineering Sciences from Université catholique de Louvain, Belgium. After a post-doc in the National Center for Computational Hydroscience and Engineering (USA) he joined the Fluid Mechanics for the Built and Natural Environment Group of CERIS, Instituto Superior Técnico, where he participated in the development of MiCas and in the development of imaging techniques. He is currently working in the University of Bologna on Acoustic Doppler signal processing. He is the IAHR Experimental Methods and Instrumentation committee (EMI) chair for the period 2015-2017. As EMI chair, he co-organized the W.A.T.E.R. Summer School and HydroSenSoft 2017 conference.

Mário Franca is Research and Teaching Associate at the Laboratory of Hydraulic Constructions of the École polytechnique fédérale de Lausanne, holds a position as Assistant Professor (on leave) at the New University of Lisbon, and is senior member of the Marine and Environmental Sciences Centre (Coimbra). His domain of activity includes hydraulic processes within the river basin. His research focus on fluvial turbulent flows; sediment transport; fluvial morphodynamics; density currents; and hydropower production in supply networks. He belongs to IAHR leadership teams of Experimental Methods and Instrumentation and Fluvial Hydraulics committees.

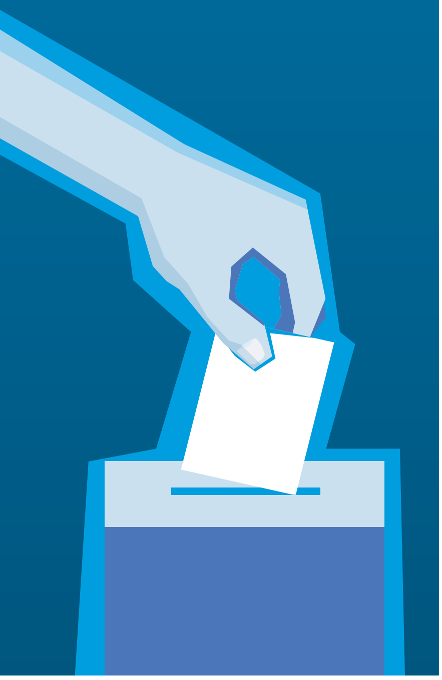
YOUR VOTE COUNTS!

The Nominating Committee has now completed its work and proposes the slate of candidates herebelow for the vacant council positions.

The IAHR Council Elections are open until Wednesday August 16th.

All IAHR Members have been invited to vote by electronic ballot. If you have not received your ballot please contact Elsa Incio at *elsa.incio@iahr.org*

For more information on this election procedure visit www.iahr.org under About IAHR / IAHR Council / 2017 Council Elections or contact Elsa Incio at *elsa.incio@iahr.org*



IAHR 2017-2019 COUNCIL ELECTIONS

For President

Prof. Peter Goodwin
(eligible for second two-year term)
DeVlieg Presidential Professor of Civil Engineering and founding Director, Center for Ecohydraulics Research, University of Idaho USA

Peter Goodwin is the Idaho Director for the Experimental Program to Stimulate Competitive Research (EPSCoR) of the National Science Foundation. He was appointed the Lead Scientist of the California Delta Science Program for the US Geological Survey and the California Delta Stewardship Council from 2012-15. Goodwin earned his Ph.D. in Civil Engineering from the University of California, Berkeley. He served on the IAHR Council from 2003-2007 and as Vice President from 2007-2011.

Statement
I am honored deeply to be selected by the Nominating Committee as candidate for re-election as President of IAHR. The greatest challenge facing society is maintaining and improving the quality of life within a healthy earth system. Population growth and climate change make balancing the reliability of a clean water supply with a sustainable but desirable ecosystem fundamental to addressing this challenge. IAHR is poised uniquely to make major contributions to the science and engineering that will inform these critical management decisions and best practices. Our community includes many of the world's leading experts and research organizations with relationships that span the globe. This is a pivotal moment in the development of IAHR as the capacity of the Secretariat has recently doubled with the opening of the second office in Beijing. If re-elected President, my agenda will be to continue our collective efforts to create a truly global and cohesive organization, forging strategic partnerships, advancing integrated modeling, enhancing committee networking and promoting opportunities for young professionals.

Comprehensive solutions to water challenges frequently require expertise from multiple disciplines drawn from the private, academic and government sectors. IAHR will explore where strategic collaborations with international agencies and other professional learned societies could provide most impact and benefit to our membership. Examples include international professional qualifications, best practices in assessing adaptation to climate change, sustainability and resilience, technical support, a new webinar series and expanding the influential IAHR monographs or white papers series.

New monitoring technologies, modeling of complex dynamic systems, visualization and communication are increasingly important. Our committees are engaged in all aspects of the water cycle from the cryosphere to coastal waters encompassing observations, managing the ever-increasing deluge of information in the era of 'Big Data', and developing models that capture our current understanding of complex systems. IAHR will actively support these activities of our Technical Committees and activities such as the recent workshop jointly hosted by IAHR and many partner organizations in California.

IAHR has had a Task Force assessing the future of IAHR and in Kuala Lumpur we will be reaching out to Technical Committees and Divisions, seeking input on innovations to strengthen and grow our collegial association. There will be opportunities for input and we welcome the engagement from individual and institutional members on ideas to (a) improve accessibility to IAHR services, (b) facilitate swift responses to innovative ideas from members, (c) respond to requests for support from agencies and institutions, and (d) enhance education and professional development opportunities.
The Council has appreciated the ideas from Young Professionals Networks (YPNs) and these concepts will seed the process in the coming months. IAHR has always been a place for more senior members to mentor rising stars and we will grow master classes, engage YPs in Committee activities and through the YPNs enhance networking opportunities for international relationships that often last a lifetime.

The foundational work in restructuring IAHR over the past 5 years and our global yet collegial culture, places IAHR in a unique position to assist in addressing the major water challenges facing society. As President, I will continue using these assets to promote IAHR on the global stage. Most importantly, IAHR is *your* professional organization and I welcome your engagement to improve the effectiveness of the association.

For Vice-President Americas

Prof. Arturo Marcano
(second term)
Professor, Andres Bello Catholic University, Venezuela

He holds a Civil Engineering degree, Major in Hydraulics from the Central University of Venezuela (Caracas, Venezuela).
In 1978, he continued postgraduate Studies in Hydraulics, Hydrology and Coastal Dynamics at University of Strathclyde (Glasgow, UK). Currently, He is an Aggregate Professor of Hydraulic Engineering at Andres Bello Catholic University, in Puerto Ordaz, Venezuela and a visiting Professor at Los Andes University at Merida, Venezuela.

He developed a 30 year carreer in dam hydraulics at EDELCA Hydraulics Laboratory, where he and his group encompassed laboratory and, numerical modeling studies and prototype monitoring, applied to the design and operation of some of the largest existing hydraulic structures built, part of the 17200 MW Lower Caroni Hydroelectric Development. His topics of interest have been design, and operation of large hydraulic structures, energy dissipation, aeration, large river diversion schemes, model and prototype correlation, implantation of large hydroelectric projects and education in hydraulic engineering.

Presently, in parallel with his teaching activity, he has developed a consulting activity in dam hydraulics engineering applied to more than 20 projects in Ethiopia, Guatemala, Panama, Pakistan, and in Venezuela. Since 2006, he has worked at the Orinoco Delta, monitoring hydraulic structures behavior, erosion and sedimentation processes, salinity intrusion and, water quality. He has served as Adviser of several public and private companies and provided assistance to hydraulic and environment engineers of CORPOELEC (Venezuelan Corporation of Electricity) in Dam and Reservoir Management. He has imparted courses and training to hydraulic engineers of the National Hydraulic Laboratory, Ministry of the Environment, in Venezuela. He is a member of the Hydraulics for Dam Committee of ICOLD.

He joined IAHR in 1982, and has served the organization in various capacities; he has been an active member of the IAHR Hydraulic Structures Committee, Chair of the Second Symposium of Hydraulic Structures (2006), and Chair of the XXII Regional Latin American Congress in 2006, past Chair of IAHR LAD (2006-2008). Member of Scientific Committees of IAHR Specialty conferences and Regional Congresses. He helped implantation of Hydro List for the IberoAmerican IAHR Community. He became an elected member of IAHR Council in 2011. He has motivated many engineers, scientists and organizations from Latin America to join IAHR, attend and support IAHR Conferences and Congresses.

Statement
As Vice president of IAHR I will:

- Continue promoting IAHR activities in Latin America, Increase links between IAHR and Latin American universities, Research Centers and Professional institutions from the region can benefit from workshops, seminars, and technical exchange, and IAHR can gain knowledge and expertise from LA experiences.
- Assist IAHR in increasing membership, I will work to promote IAHR in Central and South America.
- I will continue giving support to organizations of the Biennial IAHR LAD Congresses.
- I will provide advice and support to the LOC of the 38th IAHR World Congress to be celebrated in Panama City in 2019.

SLATE OF CANDIDATES

For Vice President Europe **2 candidates for 1 position**

Dr. Damien VIOLEAU
Senior Research Scientist
Laboratoire National d'Hydraulique et Environnement
EDF R&D
France

Damien Violeau has been working since 1997 at the Laboratoire National d'Hydraulique et Environnement of EDF R&D, where he was appointed Senior Scientist in 2013. He is also involved in the Laboratoire d'Hydraulique Saint-Venant, created in 2006. His main activities are the development of the Smoothed Particle Hydrodynamics (SPH) numerical method and the design of coastal water-works, with an additional contribution to turbulent processes in the environment and the physics of tsunami waves. He compiled his work on theoretical fluid mechanics, SPH and its application to waterworks in a 600+ page book published by Oxford University Press in 2012. Besides his research activities, he developed a long and fruitful teaching experience, as lecturer in several engineering colleges in France, in particular Ecole des Ponts ParisTech, where he has been teaching Fluid Mechanics since 1998, and at Ecole Normale Supérieure de Cachan.

Damien was introduced to IAHR in 2003, first as a member of the Hydroinformatics Section, then as a member of the Maritime Section (now Committee on Coastal and Maritime Hydraulics) where he was secretary from 2006 to 2007. He participated to the Biennial congresses since then, as well as many other IAHR congresses, as speaker, chairman and organizer of special sessions. He is also a regular reviewer of JHR, and was appointed Associate Editor in January 2015. He was a co-opted member of the Council in 2013 and participated to the Council meeting in Porto that year. Since then, he started to think about the way to improve the links between Industry and Academia in IAHR. He also built and supervised the Paris IAHR YPN (officially closed in 2016).

Damien has also been a member of ERCOFTAC and is a member of the French Hydro Society (SHF). In 2005, he created the SPH European Research Interest Community which he chaired until 2009.

Statement
If elected, Damien Violeau will work to:

- Continue to increase relations between Academia and Industry within our community
- Develop the interest in water and hydro-environmental sciences in Universities, in particular using the YPN network
- Promote IAHR and enhance exchanges with other existing scientific communities (in particular the French Hydro Society)
- Help in keeping IAHR a dynamic community in the (near) future, by attracting new young scientists and trying to foster communication between the latter and the most experienced members
- Promote more communication between specialists of connected areas (e.g. sediment and turbulence; waves and coastal currents, coastal and river flows, etc.)
- Foster the use of recently developed numerical methods for fluids and High Performance Computing in order to extend the capabilities of CFD to a wider range of applications in hydraulic engineering

Prof. Silke Wieprecht
Universität Stuttgart
Department of Civil and Environmental Engineering
Institute of Hydraulic Engineering
Germany

Silke Wieprecht is a full professor at the University of Stuttgart, Institute of Modelling Hydraulic and Environmental Systems. She holds a Diploma degree as Civil Engineer (TU Munich) and finished her dissertation about "Sediment transport and bed forms in gravel bed rivers" in 1998. After two years as consultant engineer she joined the Federal Institute of Hydrology being responsible for the morphology of navigable rivers in Germany. In 2003 she received a tenure position as Full Professor at the University of Stuttgart. During her professional career she passed several research stays at international universities in China, Malaysia, Norway, and in 2017 also South Africa.

Sediment transport is her passion in research. However, her scientific approaches are on a highly multidisciplinary level working in an international network together with engineers, biologists, ecologists, chemists, sociologists and others.

Since the end of the 1990ies she is strongly tied with the activities of IAHR. It started and it still applies with exchange in the technical sections (rivers, fluvial, sediments, flood risk management). In the last years her activities developed also in a more strategic commitment e.g. in the European Regional Division (4 years) and in the Council (since 2013). Since several years, she is the advisor of the (former student chapter and now) YPN in Stuttgart. Since 2013 she also holds the position as Chair of the Young Professionals Committee in IAHR. As Course Coordinator of the International Master's Program WAREM, where students from all over the world come to Stuttgart, she is in her everyday life part of an international environment with young professionals, all of them highly engaged in the water sector.

Statement
Young professionals are the future and the lifeblood of our organisation. This is the reason why YPN and the active engagement with them are of high concern for me. The topic of support and promotion of YPN, especially in cooperation with universities but – at least of the same significance – also with companies and industry, is from my point of view of major importance.

IAHR as a relative small (compared to others e.g IWA) association should tie strategic collaborations and foster solidarity with other organisations being active in comparable or neighbouring fields (IWA, ICOLD, IAHS, and others). as an adequate member of a superior alliance with the aim to play an essential role in the larger international context, like e.g. the World Water Council.

In 2016 I guided the Taskforce "Gender Equity", where we analysed the actual situation of gender distribution within IAHR and developed ideas for potential measures to increase the number of female members. I would be happy to encourage especially the younger generation of women to actively participate in our association work and step up for leading positions.

For Vice-President Asia Pacific

Prof. James E. Ball
(second term)
Associate Professor, School of Civil and Environmental Engineering
University of Technology Sydney, Australia

James Ball is a Professor in the School of Civil and Environmental Engineering at the University of Technology Sydney, in Sydney Australia. His primary research interest is in the development and application of catchment modelling systems for flood estimation in both Urban and rural catchments. This includes the determination of parameters for these systems and the use of information technology in the determination of these parameters. Through these research activities he has published a number of book chapters, over 50 journal papers and 170 referred conference papers.
In 2011 he was awarded the JC Stevens Award by the ASCE for his publication in the Journal of Hydraulic Engineering.

Prior to joining the University of Technology Sydney, Professor Ball obtained experience through research undertaken at universities in Australia, Canada and USA. Professor Ball also obtained experience as a Consulting Engineer and in Government Authorities.

He is a member of the editorial boards for the Urban Water Journal, the Journal of Hydroinformatics, and is an Associate Editor for Water Science and Technology and the Journal of Applied Water Engineering and Research.

Statement
I am honoured to have been selected by the Nominating Committee for continuation in the role of a Vice President of IAHR. I am a member of the School of Civil and Environmental Engineering at the University of Technology Sydney. Due to my role as Editor of the revision to Australian Rainfall & Runoff (ARR) I have been leading a team managing the many research projects providing the necessary input into the revision of ARR. These research projects cover the spectrum from science to application and were undertaken by a variety of water research organisation including Universities, Government Agencies, and Private Organisations.

As a member of IAHR I have been able to participate in the Hydroinformatics and Urban Drainage Committees.
In addition, I was involved with organisation of the 2011 World Congress held in Brisbane, Australia. Finally, I have served four years on Council as a member representing the APD and the last two years as a Vice President representing the APD.

I believe my experience in IAHR, my commitment to IAHR and my demonstrated capacity within IAHR provides an excellent background to be an effective VP of IAHR representing the APD.

The Asian region is rapidly growing with many diverse research and application problems of interest to IAHR members. Furthermore, APD membership within IAHR is growing highlighting the relevance of IAHR to these problems. This illustrates the appeal of membership in IAHR to the full spectrum of activities (science to application) in the hydro-environmental sciences. This desirability of IAHR membership is important if IAHR is to remain the pre-eminent Association in the hydro-environmental sciences.

IAHR 2017-2019 COUNCIL ELECTIONS

For Council Member Asia Pacific **2 candidates for 1 position**

Prof. Azazi Zakaria
River Engineering and Urban Drainage Research Centre
University Sains Malaysia
Malaysia

Statement
I fully accept the nomination as a Council Member for IAHR representing Asia-Pacific region.

I would advance the interest of IAHR as follows:

a) Promoting conferences/congress organized by IAHR at regional (APD-IAHR Congress) and Biennual World Congress

b) Increase the new members of IAHR especially for new graduates at South East Asia (SEA) Region

c) Promoting Sustainable Water Management ar SEA region

d) Improving the guidelines for PCO, DMC as well as IAHR in World Congress in the future to avoid difficulties for LOC

e) Increasing the income of IAHR from both world congress as well as IAHR-APD.

Prof. Vladan Babovic
National University Singapore
Singapore

Statement
It is an honour to be nominated as a candidate for IAHR Council to represent Asia-Pacific region. Having been an active member of IAHR for more than 25 years, and living in South East Asia for more than 16 years I envisage the following activities:

• Academia and Practice
My professional career reflects strong interests in scientific research and making it societally relevant by addressing sustainability-related challenges. Prior to my present position at National University of Singapore (NUS) I worked at specialist consultancy organisations, such as Danish Hydraulic Institute and Delft Hydraulics. As a result, I believe that one of the skills I can bring to the IAHR Council is to strengthen the bridges between academic and applied hydraulic engineering.
• Societal relevance of hydraulic engineering
The challenges posed by accelerating urbanisation and climate change require sustainable management of water resources. As a council member I would advocate approaches that leverage science into practicable, societally-relevant and viable solutions, especially with regard to use of advanced information technology in water management, linkages between food, water and energy use, as well as development of climate-resilient communities.
• Technology and its impact on the profession
Management of water calls for the utilization of the most advanced science and technology for the purposes of better understanding and management of the looming water crisis. I am interested in advancing emerging techniques for studying hydraulics through use of new methods such as machine learning and artificial intelligence. Technology is overturning not only the world's economies, but also bears a major impact on our profession. As IAHR council member I would advocate continued advancements of fundamental hydraulics enhanced by latest IT developments.
• Geographical outreach
Asia-Pacific and South East Asia, with population exceeding 4.5 billion people, is home to almost 60 per cent of the world's population. The strategic geographic location of Singapore makes it feasible to reach out to many new IAHR members as well as more actively engage existing members. As a council member I would endeavour to mobilise broad network of colleagues from the region, with a specific attention to proactively involve the nations that are opening up. I would strive to enhance the IAHR relevance through more frequent specialist meetings as well as increase IAHR visibility and thought leadership at large global events (such as Singapore International Water Week which attracts 17,000 professional bi-annually).
• Professional outreach
In addition to being a member of IAHR, and I am elected fellow of International Water Association (IWA) and play an active role in International Association of Hydrological Sciences (IAHS), European Geosciences Union (EGU) and American Geophysical Union (AGU). Strong IAHR can benefit from even stronger ties and collaborative initiatives with these and other relevant professional organisations and associations. As an IAHR council member I would endeavour to promote the influence of IAHR in such professional circles.

For Council Member Asia Pacific

Prof. Pengzhi Lin
Sichuan University
China

Prof. Pengzhi Lin obtained his Ph. D. degree from Cornell University in 1998. He stayed at Cornell for one year as a Postdoctoral Associate before he went to Hong Kong Polytechnic University as a Postdoctoral Fellow. In 2000, he joined National University of Singapore as an Assistant Professor and became the tenured Associate Professor in 2005. Now he is Changjiang Scholars Professor in State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, China.

His research interests cover hydraulic, coastal and ocean engineering. He is an expert in computational hydrodynamics and its applications in various water-related problems. He is the author of the book "Numerical Modeling of Water Waves" published by Taylor & Francis. He has published over 70 peer-reviewed journal papers, which receive a total SCI citation number over 2,000. He is currently the Chief Editor of Applied Ocean Research and the Associate Editor for Journal of Hydro-environment Research, Journal of Hydraulic Engineering, and Journal of Ocean Engineering and Marine Energy. He is also the editorial board member of Ocean Engineering, Journal of Earthquake and Tsunami, and Engineering Applications of Computational Fluid Mechanics.

Prof. Lin served as the General Secretary for IAHR World Congress 2013 held in Chengdu, China. Starting from 2009, he has been actively involved into the preparation and coordination works for this World Congress. Currently, he is the EC member of IAHR-APD and a member of IAHR Coastal and Maritime Hydraulics (CMH) Committee. Being the CMH member, he is planning to bring the CoastLab 2020 into China, the first time for this conference held in Asia. He will also deliver a keynote speech in the upcoming IAHR 2017 World Congress. Serving as an Associate Editor of Journal of Hydro-environment Research, he has been helping promote and maintain the high quality of this IAHR-ADP sponsored journal.

Statement
I really appreciate the opportunity of being nominated to represent Asia-Pacific region as a council member of IAHR. Being with IAHR for many years, I would like to continue my services to this great association in the following aspects:

1. Further promote and widen the IAHR's membership coverage, especially in Asia-Pacific Region and for students and young researchers & engineers.
2. Meet the new challenges of water related problems due to climate changes and fast urbanization in Asia-Pacific areas.
3. Expand the impact of IAHR by bringing more activities in this region, outreaching to local authorities and practioners, and soliciting more high-quality publications to IAHR journals.

SLATE OF CANDIDATES

2 candidates for 1 position **For Council Member Europe** **2 candidates for 1 position**

Dr. Zhongbo Yu
State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering
Hohai University
Nanjing, China

Dr. Yu received his PhD from Ohio State University in 1996 and has been professor in University of Nevada Las Vegas. He is a Distinguished Professor of Thousand Talents Program of China and Chair Professor of Cheung Kong Scholars Program at Hohai University in China, where he was also Dean of the College of Hydrology and Water Resources and currently is Director of the State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering.

Dr. Yu has extensive research and teaching experience in climate change, hydrology and water resources. He has completed over 50 research projects including grants funded by the National Basic Research Program of China (973 Program), National Key R&D Program of China, National Science Funds for Creative Research Groups of China, the program of Dual Innovative Talents Plan and Innovative Research Team in Jiangsu Province, National Natural Science Foundation of China, National Science Foundation of America, United States Department of Energy, and United States Department of Agriculture. He has published more than 200 SCI papers, over 10 patents, and 2 monographs. His book chapter-Hydrology: modeling and prediction-was included in the Encyclopedia of Atmospheric Science and his hydrology model system (HMS) was collected in large watershed models. Dr. Yu has received a number of awards for excellence in research and teaching. He was awarded with the National Prize for Progress in Science and Technology 2015, with the First Prize of Dayu Water Science and Technology 2013 and 2016, with the John Hem Award of United States National Groundwater Association 2015, and many more. He is fellow of Geological Society of America.

Dr. Yu has applied his capabilities as a researcher for the betterment of society with an unwavering focus on addressing critical problems in hydrology and climate change affecting China and other countries. He has mentored 39 PhD students and more that 30 international scientists. His service to society extends to his passion as a teacher and educator, committed not only to educating the next generation of professionals and academics for China and other countries (e.g., Nepal, Germany, USA) but to showing them how to lead the world in hydrologic sciences. He is the vice chair of Chinese National Committee of UNESCO IHP and of Chinese National Committee of IAHS, chair of IAHR groundwater committee, editors of Water Resources Research, Journal of Hydrology, Journal of Contaminant Hydrology and many more.

Statement

If elected, Zhongbo Yu will strive to:

- Work to promote international collaboration among university, government and industry, particularly between Asia-Pacific region and rest of the world.
- Further develop the joint international laboratory with Desert Research Institute, UCLA, University of Waterloo, and TUDelft.
- Continue to participate in all fronts of IAHR activities including being Chair of IAHR Groundwater Committee and attracting young generation scientists.
- Organizing 2018 IAHR Conference in China on Global change challenge: water security and sustainability.

With his extensive international experience, he is willing to extend his service to further International Association for Hydro-Environment Engineering and Research.

Dr. Ioana Popescu
UNESCO-IHE
The Netherlands

Statement

If elected my contributions in the Council will be in the following important areas:

- In the past years my main activities in IAHR were strongly linked with the Young Professionals Committee, where I also served as a Chair in 2011-2012. In this position I could see that Young Professionals and the corresponding network is an important element of the organisation, therefore I see it very important to promote and support the YPN, especially creating opportunities for an improved collaboration between fresh graduates and industry. Moreover strengthening YPN would envisage creating more possibilities for communication between the experienced members of IAHR and YPN.
- Linked with the above it is very important to strengthen the link between industry, companies and academia so that universities are collaborating together with industry, not only to prepare better graduates but also to understand what are the technological needs of the industry.
- Collaboration with other international engineering associations that are active in the hydro-environment, creating links for research. As such IAHR will remain an important player in the world of water and will foster research in water related areas. Such activities will be supporting the aim stated in IAHR's 2015-2019 strategic plan to become an international community of research and best practice.
- Promote communications of specialists between different Technical Committees within IAHR to create stronger interdisciplinarity.

If elected I will collaborate and work together with the Council members, Executive Committee and Secretariat officers to achieve the objectives of the IAHR Strategic Plan.

Prof. Olivier Métais
Grenoble Institute of Technology/Ense3
France

Statement

During my entire career, I have been actively involved in research activities applied to hydro-environmental sciences.

As a founder of an internationally renowned school of engineering devoted to energy, water and environmental sciences, I have constantly worked towards the advancement of the links between top-level training, research and industry as well as international openness. The school I have directed is part of the Grenoble Institute of Technology and therefore belongs to a very large multidisciplinary international network of alumni and young professionals. This could constitute a significant asset towards reaching some of the objectives of the IAHR strategic plan: expansion of the young professional network (YPN); promotion of interfaces between disciplines in connection with hydroscience; development of innovative tools for Continuing Education.

For many years, I have been involved in various boards and councils in France and Europe with the objective to contribute to the definition of strategic guidelines for the development of innovative research, of industrial applications and of productive interactions between the academic and engineering worlds. My expertise in these domains could constitute an effective support to the IAHR towards reaching its strategic objective of enhanced collaboration between research and engineering communities.

Since IAHR plays a major role in this development in the field of hydro-environmental sciences and their practical applications, I am very motivated to become a member of the IAHR Council and to actively participate in the development of the Association along its current strategic guidelines and to contribute to the elaboration of its future orientations.

IAHR AIRH

International Association for Hydro-Environment Engineering and Research

Supported by
Spain Water and IWHR, China

IAHR 2017-2019 COUNCIL ELECTIONS

For Council Member Europe **2 candidates for 1 position**

Prof. Dragan Savic
University of Exeter
UK

Professor Savic is a founder and co-director of the Centre for Water Systems (www.ex.ac.uk/cws), in the College of Engineering Mathematics and Physical Sciences (CEMPS) at the University of Exeter (United Kingdom), which is an internationally recognised group for excellence in water and environmental science research. He is a Chartered Civil and Water Engineer with over thirty years' experience in research, teaching and consulting. His research interests cover the interdisciplinary field of Hydroinformatics, which transcends traditional boundaries of water/ environmental sciences, informatics/ computer science (including Artificial Intelligence, data mining and optimisation techniques) and environmental engineering. Applications are generally in the hydro-environmental science/ engineering areas, including water resources management (both quality and quantity), flood management, water & wastewater systems and environmental protection & management.

Prof. Savic has served as Vice Chair and Chair of the IAHR/IWA/IAHS Joint Committee on Hydroinformatics and as the Editor-in-Chief of the Journal of Hydroinformatics. He is a Fellow of the Royal Academy of Engineering (UK), Member of the European Academy of Sciences and Fellow of the International Water Association (IWA).

Statement:
- As somebody who has a long association with IAHR and IWA, including being a Fellow of IWA and a member of two joint IAHR/IWA committees, I intend to build further links between the two organisations with the aim of increasing impact of our profession on the society and promoting its influence on policy.
- I intend to make further significant contributions by promoting IAHR as one of its ambassador's, by promoting excellence and further development of the profession, and by promoting research excellence in the areas related to information technology in aquatic and urban environment via the Joint Committee on Hydroinformatics and the joint Urban Drainage Committee.
- In the age of 'smart cities' where around 4 billion human beings rely on urban infrastructure to make urban environment inclusive, safe, resilient and sustainable,
  I will work with IAHR collegues to influence the smart city proponents and include in their plans the often neglected water issues.
- Finally, as a researcher I am committed to promoting scientific excellence and best practices, particularly in my own area of research related to Hydroinformatics.

Prof. Vladimir Nikora
National University Singapore
Singapore

Professor Vladimir Nikora is Sixth Century Chair in Environmental Fluid Mechanics at the School of Engineering, University of Aberdeen (UK), where he serves as Leader and Academic Line Manager for the Fluids and Structures Research Group. His main research areas relate to turbulent flows, sediment dynamics, hydraulic resistance, flow-biota interactions, and experimental methods. He has published extensively on these topics and initiated informal research networks to promote novel ideas in waterway hydraulics such as double-averaging methodology for rough-bed flows. Professor Nikora has been an Editor of IAHR Journal of Hydraulic Research and Associate Editor for AGU Water Resources Research and ASCE Journal of Hydraulic Engineering. He is currently one of Advisory Editors for the IAHR Journal of Ecohydraulics. Over the years, he has been a contributor to the IAHR Experimental Methods and Instrumentation Committee (Section) as a member, Secretary and Chair. Professor Nikora is Fellow of the Royal Society of Edinburgh, Scotland.

Statement
If elected, I would particularly contribute to the Council work in the following areas:
- Refinement and maintenance of high-quality publication portfolio and strategies. IAHR publications remain among most attractive outputs of the Association and therefore need constant attention to meet traditional and emerging demands of the IAHR community. I believe my recent experience with JHR and other editorial works would help enhance and diversify this activity.
- Interdisciplinary research. Modern engineering has increasingly become inter- and multi-disciplinary and this global tendency is to be reflected in the expansion of current IAHR subject areas. I would help develop IAHR activities at the interfaces with research and applications related to aquatic ecology, renewable energy, geophysics, hydrology, geomorphology, and social sciences. This would also strengthen linkages with other professional organisations (e.g., AGU, ASLO and similar) and help attract new membership from non-traditional fields.
- Emerging engineers and researchers. Over recent years, IAHR has significantly augmented attention to early career hydro-environment professionals. This area needs constant consideration and I would regard it among top priorities, helping to build a strong cohort of emerging hydro-environment engineers and researchers.
- IAHR family. The current representation of different countries at IAHR remains uneven and I would undertake efforts to strengthen IAHR influence and activities in under-represented countries.

For Council Member Americas

Prof. Robert Ettema
Colorado State University
USA

Statement
Preamble
I presently am serving as as a co-opted member of IAHR's Council, and I am keen to serve as a North American representative on IAHR's Council. A vibrant and engaged IAHR is vital for water engineering in North America.

Intent
In my view, the following considerations are foremost for the North American representative:
1. Represent both the USA and Canada, as the two countries comprise the constituency of the North American representative.
2. Foster enthused engagement. A foremost task for the North American representative is to foster and stimulate the engagement of IAHR's immediate constituents in the USA and Canada– students, researchers, educators, practitioners. This task requires further building up of IAHR's membership, including corporate and governmental organizations.
3. Increase USA and Canadian participation. A trend in recent years has been a relative decline in IAHR membership of individuals as well as U.S. and Canadian organizations. Reversing this trend involves heightened, thoughtful marketing of the value of IAHR membership and products (notably, research findings, improved designs, education mechanisms, consultant expertise).
4. Sharpen image. My impression is that IAHR does a good job presenting and promoting itself, but I see the need to sharpen IAHR's image, especially for people not directly involved in university-based research. For example, IAHR's website needs a clearer message regarding IAHR's purpose and products. Also, the website should promote philanthropic giving to IAHR activities. This latter effort entails strengthening IAHR's appeal to potential donors.
5. Aid IAHR develop a fiscal model that facilitates IAHR's purpose. A broadened income model is needed. In addition to continued reliance on the traditional source of income (membership dues), together with modest earnings from IAHR products (e.g., conferences) the fiscal model must increase gifting as a source of funds. A broadened income model must be embraced by IAHR's divisions as well as IAHR as a whole.
6. A reputation of high quality. Besides considerations of fiscal bottom-line, it is critically important that IAHR continue to promote its reputation for high quality products (publications, conferences, education mechanisms). Where IAHR sees advantage in partnering with other organizations to create quality products, it should judiciously do so.

I appreciate the honor of being nominated to serve as North American representative to IAHR's Council.

38th IAHR World Congress

“WATER: CONNECTING THE WORLD“

38th IAHR PANAMA 2019

IAHR AIRH

Supported by Spain Water and IWHR, China

September 1 to 6, 2019
Panama City, Panama
RIU PLAZA PANAMA HOTEL

THEMES TO BE COVERED:

- HYDRAULIC STRUCTURES
- PORTS and COASTAL Engineering
- HYDRO-ENVIRONMENT
- WATER MANAGEMENT and HYDRO-INFORMATICS
- RIVER and SEDIMENT MANAGEMENT
- CLIMATE CHANGE and EXTREME EVENTS

AIR TRAVEL HUB:
Considered one of the best airports in the region and strategic point to connections between the Americas, the Tocumen International Airport receives annually more than 14 million passengers, connecting 20 airlines, over 83 destinations in 35 countries, throught the Americas and Europe.

CONGRESS HOUSING:
While the elegant RIU PLAZA PANAMA HOTEL will serve as the main Congress venue, Panama city host a wide variety of additional housing choices from upscale hotels to bed and breakfasts nestled in residential sections. A cosmopolitan city, it has something to fit every attendee’s budget, including the opportunity for very attractive student and/or delegate housing at the City of Knowledge.

CONGRESS TOURS:
Congress technical tours will take you to the Old and New Panama Canal Locks, ships transits through the Panama Canal Locks, and visits to the Gatun Lake. Leisure tours will include tours to the Old Panama city, train tour to the Atlantic side, and visits to the Frank Gehry BioMuseum.

CONGRESS VENUE:
Panama City was founded in 1519, being the first Spanish city on the shores of the Pacific Ocean. With a skyline filled with modern buildings, the city is well known for its business structure, 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 21th 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 unusual places, Panama City is a magical and fascinating destination. The Congress will provide every participant with a life-time memorable experience.

Hosted by the City of Knowledge
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Plan to join us in 2019!

FORREST M. HOLLY JR. (1946–2017)

Forrest Merton Holly Jr., distinguished hydraulician, leader in civil engineering, and stimulating companion, passed away on Monday, May 22, 2017. His professional life was filled with significant advances in computational hydraulics, understated leadership, and many interests that he pursued energetically. He gained the esteem, gratitude, and affection of the many people with whom he came in contact. His service as IAHR president (2000–03) reflected his genial, highly competent approach to the tasks he tackled.

Forrest Holly, a native of La Jolla, Calif., completed his undergraduate studies at Stanford University in 1968. He went on to earn the MS degree from the University of Washington and in 1975 obtained the PhD degree from Colorado State University. His PhD thesis was titled Two-Dimensional Mass Dispersion in Rivers. His thesis advisers at Washington and Colorado State were noted hydraulicians Ron Nece and Daryl Simons, respectively. In the course of attaining his formal education, Forrest worked short periods with the U.S. Army Corps of Engineers in Vicksburg, Miss.; and with Northwest Hydraulics Consultants in Edmonton, Alberta. In 1968, Forrest married Joyce Nowry, forming a close, supportive partnership that became a delightful aspect of their interactions with friends and acquaintances.

Forrest's special expertise was in computational hydraulics, particularly the modeling of dispersion and water-quality processes and flows in alluvial rivers. Upon graduating with the PhD, Forrest worked for a year with the consulting firm Dames and Moore in Washington, D.C., then moved overseas to Grenoble, France, where he spent the next five years (1976–81) at SOGREAH (Société Grenobloise d'Etudes et d'Applications Hydrauliques). SOGREAH, an engineering firm initially associated with the hydraulics laboratory at the University of Grenoble, was renowned for its work in civil engineering hydraulics. While at SOGREAH, Forrest worked with leading computational hydraulicians Alexandre Priessmann and Jean Cunge, developing numerical models for hydraulics applications. One outcome of his work at SOGREAH was the Holly-Preissmann scheme, which became widely used for numerically solving the advection-dispersion equations formulated to describe the spreading of material or heat in flowing water. Jean Cunge, below, extends this obituary with further thoughts from Forrest's time with SOGREAH.

Seizing the opportunity to delve further into the theoretical underpinnings of computational hydraulics, Forrest became a visiting research scientist in the Mathematics Department at the University of Reading, England (1981-82). There, he pursued the development of numerical methods for modeling pollutant dispersion in two-dimensional situations of unsteady flow in rivers.

The six years Forrest spent in France and England fostered his appreciation (and frequent enjoyment) of the differences in manner and approach encountered in countries other than the USA. Additionally, his insight into the ways of doing things in various countries, along with his familiarity with hydraulicians from around the world, gave him an international perspective that energized his career development and made him well-suited to be an IAHR president motivated to advance hydraulics internationally.

However, Forrest's long-term goal was to return to the United States and to contribute to that nation's engineering education and research while living there with his family. In 1982, Jack Kennedy, then director of the Iowa Institute for Hydraulic Research (now IIHR—Hydroscience & Engineering) at the University of Iowa (UI), recruited him to join IIHR and UI, where he spent the rest of his academic career. Appointed first as associate professor, he in due course gained tenure as professor (1990). Forrest became chair of UI's Department of Civil and Environmental Engineering (1995–99) and eventually associate dean for academic programs in UI's College of Engineering (1999–2003). He retired from UI and IIHR in 2003, although he stayed engaged with some teaching and research activities.

As a UI faculty member, Forrest enjoyed teaching and working with students, and was very effective at both activities. He was popular with students, who considered him to be a motivational and articulate instructor. He gained two teaching awards while at UI. In 1991, he received the department's Chi Epsilon Outstanding Teacher Award, and in 1995 the college's Outstanding Teacher Award. Forrest was committed to the professional development of civil engineering students. From 2000–08, he was a member of Iowa Engineering and Land Surveying Examining Board, chairing the board in 2006. Also, he was a registered engineer in eight states of the USA plus Alberta, Canada; most U.S. civil engineers are registered in only one or two states.

A joke shared among Forrest's IIHR colleagues was that his first graduate-student advisee was an elderly gentleman named Frank. Nobody quite knew how Frank got admitted to UI's graduate program, and some even wondered if Frank was a homeless person, but Forrest was game enough to take him on as an advisee. One day, Frank, who usually wore an odd well-worn pin-striped suit, was sitting with Forrest when IIHR Director Jack Kennedy wandered by. Frank loudly remarked, "Who is that tall guy?" Forrest said, "That's Professor John F. Kennedy." Frank replied, "So, he's named after the president?" Kennedy tersely retorted, "No, my mother named me after the airport!" and walked on. This joke, occasionally recalled by Forrest, is indicative of the sense of fun with which he undertook his work.

Forrest never lost his keen interest in investigating complex river hydraulics and sedimentation problems and offering consultant service as a registered engineer. His areas of special research interest included computational hydraulics, dispersion in natural waters, alluvial-river processes, urban hydraulics, thermal discharges, and irrigation control systems. One research project, for example, involved numerical simulation of flow and heat dispersion from thermal power plants along the Illinois River. He published widely in peer-reviewed academic journals, and was a frequent presenter at conferences and symposia. In 1980, he co-authored a popular reference in computational methods for river processes (Practical Aspects of Computational River Hydraulics, by Cunge, Holly and Verwey, Pitman Publishing). In 1983, Forrest received IAHR's Arthur T. Ippen Award for his demonstration of exceptional ability and promise for continued research productivity. Additionally, UI selected him for a Faculty Scholarship to aid his research during the period 1985–88. He received the Hunter Rouse Hydraulic Engineering Lecture Award from the American Society of Civil Engineers (ASCE) in 2000 in recognition of his outstanding contributions to hydraulics and waterways. Twice in preceding years, 1995 and 1998, he received the Best Technical Note Award in ASCE's Journal of Hydraulic Engineering. In 2001, he received IAHR's Harold J. Schoemaker Award for his article in the Journal of Hydraulic Research. The article, Two-phase Formulation of Suspended Sediment Transport, was judged the journal's most outstanding publication in the two years preceding IAHR's 2001 World Congress.

Though living in the United States, Forrest retained his international perspective. He was an active member of IAHR for many years, serving as a member of the IAHR Council (1988–2003); becoming vice-president (1992–94); and serving as president (2000–2003). In 2007, Forrest was named an Honorary Member of IAHR, the group's most prestigious recognition. He was highly committed to serving IAHR. Also, Forrest was connected to the EuroAquae MS-degree Program in Hydroinformatics at the University of Nice Sophia-Antipolis, France. He made several trips to Nice during the period 2006–2010, participating as a lecturer and serving on its international advisory board; the program was developed by an international consortium of universities. Forrest's English translation of Pierre-Louis Viollet's book, Water Engineering in Ancient Civilizations, 5,000 Years of History, was published in 2007 as an IAHR Monograph.

As IAHR president, Forrest was responsible for moving IAHR's headquarters from Delft to Madrid, and for introducing IAHR's newly-appointed first executive director, Chris George, to IAHR's membership. Additionally, he and Helmut Kobus created IAHR's student chapter. Further, he was the only IAHR president to bring his skill as a pilot to IAHR's service. In 2000, following IAHR's Hydroinformatics Conference in Cedar Rapids, Iowa, Forrest and Chris flew to the World Bank headquarters in Washington, D.C. Forrest was also IAHR president during the 2001 World Congress in Beijing, two days after the 9/11 disaster in New York. Owing to meetings arranged by Chris George in Tokyo prior to the congress, Forrest was out of the United States when the disaster occurred and was able to manage with his characteristic aplomb and working with the LOC the difficult task of running a successful congress.

In the context of hydraulics history, mention should be made of Forrest's great-grandfather, Birdsill Holly (1822–94). Willi Hager's book Hydraulicians in the USA, 1800–2000, includes Birdsill Holly as an early engineer engaged in the manufacture of hydraulics machinery. Forrest would speak admiringly of his great-grandfather's pioneering work developing pump systems for supplying water to many communities in the United States.

Forrest always displayed a certain independence of spirit. While earnestly dedicated to the advance of hydraulics (especially computational hydraulics) and engineering education, he also set and followed his own path in life. He could have gone on further in hydraulics research or academia, but many other things drew his interest. He liked the practical aspects of engineering consulting, was an avid pilot, became a certified flight instructor, enjoyed repairing old mechanical clocks (his house ticked with them), and in later years became an enthusiastic stargazer, to name just a few interests. Forrest and Joyce moved to Arizona in 2008, in part to better pursue their interests. When he retired from UI in 2003, he founded a small engineering consulting firm, Holly and Associates. His last consulting project, completed in late 2016, involved computational modeling of water flow along a reach of the Illinois River.

Forrest Holly was a valued colleague, mentor, and friend to many people. He is survived by Joyce and their son Lance and daughter-in-law Laureen.

By Jackie Hartling Stolze, Rob Ettema, Larry Weber and Chris George

Further Thoughts on a Great Friend: Forrest M. Holly Jr.

By Jean A. Cunge

Forrest stayed with SOGREAH in France for five years, beginning in 1976. SOGREAH was a private consulting engineering company, probably one of the last, if not the last, that succeeded in carrying out engineering hydraulics and water resources projects and development and research projects at the same time. The links with the University of Grenoble were of the person-to-person kind, not formal. The reputation of the company was such that, when the idea of coming to Grenoble "for some time" was put before Forrest, he did not wait long time to accept.

Forrest was a musician—he played guitar—and he had perfect musical ear. This helped enormously in quickly learning French. At the beginning, it was rather colloquial French, but after a couple of months he was perfectly integrated within the team. His participation in development of SOGREAH's CARIMA (the world's first commercial software allowing numerical modelling of 1D-2D combined flood situations) in 1976–77 was extremely important. At the same time, given SOGREAH's position as a private consulting company, Forrest worked on engineering projects on coastal pollution, modelling urban sewage networks, and other topics. Leaders were stupefied in Marseilles when the Director of the State pollution-control authorities put before decision-makers, "the study of coastal outfall consequences presented by Forrest Holly from SOGREAH" – stupefaction because Forrest was American and his French at this time was very, very much colloquial. But the director, M. De Rouville, insisted, "He did the job, and the result is exceptional; it's up to him to present, but in French, please."

Forrest and Joyce created many personal links with colleagues at work and friends in town during their stay in France. Those links remain strong today. When they went back to the United States, Forrest was instrumental in admitting to the University of Iowa several younger engineers from SOGREAH for periods of 6–12 months. This activity was exceptional, leading to reciprocal exchanges of engineering ethics, knowledge, and working habits. The French "expatriates" of one year, such as Jean-Marc Usseglio, Patrick Sauvaget, and Jean-Luc Rahuel, all became important leaders of research, engineering, and management at SOGREAH, and then at the ARTELIA Group (the biggest private French consulting firm), and also in French hydraulics.

I feel that something concerning Forrest's family should be added. There is no doubt that Forrest's character was forged by his parents, both of whom were blind. This was an extraordinary situation that did not stop his family from living full lives. For example, his father was a building contractor. When his parents visited Europe, they went to all the famous art galleries where they admired famous paintings. Although they could not see the paintings, the artworks were described to them by Forrest's sister, who accompanied them. Forrest followed his career path far from his parents, and it was not easy for all concerned. Certainly, the family's religious convictions and faith were important, but also important were their individual characters.

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