International Water Association

# W&RBM NEWS

## Newsletter of the IWA Specialist Group on WATERSHED & RIVER BASIN MANAGEMENT

**September 2010**

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**If you want to be a volunteer, or if you have any general enquiries about W&RBM or articles for the newsletter, please contact the newsletter editor, Matthias Zessner. But please feel free to contact any of the committee members at any time**



**Deadline for submission for contributions for the next newsletter is December 15 2010**

## INTRODUCTION OF MEMBERS OF THE MANAGEMENT COMMITTEE

### Bob Crabtree

Currently, Bob Crabtree is the Environmental Management Business Development Manager at WRc plc in the UK. WRc is a research based, employee-owned private company providing consultancy in the water, waste and environment sectors. As one of four Business Development Managers, he has responsibility of technical, managerial, sales and marketing leadership of a team of over 30 scientists and engineers ranging in experience from recent graduates to post graduates with over 20 years of consultancy in the water and environment sectors. The current focus of WRc's Environment Management Business is supporting UK and overseas environmental regulators and dischargers to develop and comply with national and international environmental policy and legislation. For example, leading an international consortium to provide technical support to the implementation of the Water Framework Directive for the European Commission; and, developing policy, carrying out water quality modelling studies and developing river basin management plans to control point source and diffuse pollution problems in a number of member states.

Bob joined the national Water Research Centre (now WRc plc) in 1985 as an environmental scientist to assist with a national research initiative, the Urban Pollution Management (UPM) Research Programme. This was focused on the control of intermittent, wet weather discharges from urban wastewater systems – combined sewer overflows and storm tank discharges at wastewater treatment plants. The research produced the UPM Manual, first published in 1994. This forms the technical foundation for investment to control intermittent wastewater discharges across the UK and has resulted in major improvement in rivers and coastal waters. Over the last 15 years, Bob has focused on water quality modelling and river basin management research in the UK and overseas. This includes over 70 river basin modelling studies and a number of national and international research programmes; including leading a 10 year research programme in the UK, funded by the Highways Agency with the support of the Environment Agency, to collect data and develop a risk based model to predict and control the ecological impact of pollutants in highway runoff

Prior to joining WRc, Bob graduated from the University of Bristol in 1978 and completed his PhD at the University of Sheffield in 1981. This was followed by post-doctoral research at the University of Leeds and the University of Birmingham. The research at Birmingham, on statistical techniques for permitting urban wastewater discharges to achieve receiving water environmental standards formed the foundation for his future career in management. He was appointed as a Visiting Professor in the Department of Civil and Structural Engineering at the University of Sheffield in 2009.

Bob joined the IWA Specialised Group on WS&RBM Management Committee the in 2007.

*What was your motivation to work in the field of watershed and river basin management?*

Looking back, I first became aware of water pollution in the 1960s in my home town of Rochdale in the North West of England. At that time, the River Roch flowing through the town centre was black and lifeless due to discharges of industrial and sewage effluents. A vivid memory I have is of walking across a bridge in the town centre and choking from the 'rotten eggs' smell of hydrogen sulphide coming from the river. I guess that this was my first experience of river pollution and maybe triggered my later interest in river basin management and water pollution control. Forty years later, fish have returned to the river due, in part, to studies that I've been involved in.

*What is the motivation for your engagement within the IWA Specialised Group on WS&RBM*?

My main motivation is to share my practical experience of river basin management and, in particular, water quality modelling. I think that this practical experience, coupled with continued involvement in academia, gives me the ability to take a pragmatic approach based on up to date research and sound environmental science and engineering in advising on, and delivering, river basin management studies.

*What do you think are the main challenges in watershed and river basin management within the next years?*

We all talk about integrated river basin management, but what we usually mean is integration of water resources within a river basin without considering wider social, economic and environmental issues within and beyond that river basin. We need to take a more holistic approach to improving the sustainability of our global environment in response to wider issues such as, for example, climate change, population growth and depletion of natural resources. I think that our greatest future challenge is to achieve integrated, sustainable water cycle management across river basins.

## IWA World Water Congress in Montreal

As part of the IWA World Water Congress programme our specialised group on Watershed & River Basin Management has organised a special workshop together with the Global Environmental Flows Network (eFlowNet). It is entitled "Climate Change Impacts on Watershed Management: Challenges and Emerging Solutions" and will be held on Tuesday, 21.09.2010. This workshop will cover a number of challenges including the need to balance environmental, social and technical issues. Governance, particularly cross-boundary, and implementation topics are additional subjects of matter which tighten this already complex situation. Climate change will alter these challenges. Some may deepen through increasing competition for scarce resources, increased demand for hydropower and its associated environmental impacts. The future ecological and environmental development may cause substantial changes in the response of watersheds. Dealing with that process isn't quite easy because of the given challenge of managing the uncertainty in climate change predictions. However the challenges of climate change may present an opportunity or an impetus to improve watershed management approaches.

On the occasion of that congress the specialised group on Watershed & River Basin Management will held a meeting which is open for all who are interested in this topic. It is scheduled on Tuesday, 21.09.2010, from 12:45 until 14:15 in room 7 of the conference building. Please feel free to take part in that meeting, to introduce your thoughts and ideas in the wide theme of water management and to discuss upcoming tasks in that field of action.

## Ruhrverband wins IWA Award

The Ruhr River Association (Ruhrverband), one of the water associations in the state North Rhine-Westphalia of Germany being responsible for an entire river basin, has won the IWA – Marketing and Communications Award 2010 in the Category "Best promoted water protection activity or programme". This award is given for the "Ruhr Water Quality Report", a yearly voluntary publication on the results of Ruhrverbands work in water management. The handing over of that award will take place during the IWA World Water Congress in Montreal.

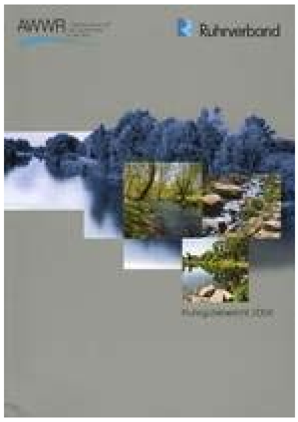
The Ruhr River Association has the task to regulate and balance the flow of the River Ruhr and to ensure a sufficient water quality. For that purpose he plans, builds, finances, operates and maintains necessary reservoirs, waste water and storm water treatment plants and impounding lakes. The success and efficiency of that work is controlled by a constant examination of the effluent of operating facilities and the quality of water in rivers, lakes and reservoirs. Fulfilling the task is done by a constant dialogue with the association's members which are cities, communities, districts, waterworks and industrial companies in the catchment area of the Ruhr.

In order to represent the outcomes of its work the Ruhr Water Quality Report was created in 1973. From its beginnings, this report was the central voice of water quality management in the natural catchment area of the Ruhr. After all, not only the Ruhrverband, but also the working group of Ruhr waterworks (Arbeitsgemeinschaft der Wasserwerke an der Ruhr, AWWR) publishes its annual analysis results, evaluates trends and presents its own activities in the report which is usually published in early September for the previous calendar year. This ensures up-to-date measured data and their evaluation against the background of currently valid immission requirements as well as future regulations currently subject to discussion.

The data documented in the Ruhr Water Quality Report are an important basis for decisions and future actions. The water examinations supply information about the origin, behaviour and persistence of substances in the aquatic environment in the River Ruhr and its tributaries. Special monitoring programmes for a comprehensive chemical and physical monitoring of the water quality and a constant hydrobiological stock-taking of the aquatic biocoenosis deliver necessary information for the observation of regional and chronological developments and for the evaluation of the waters' ecological condition. These results form the basis for drawing up, planning and carrying out future measures.

All in all, the Ruhr Water Quality Report serves as a compendium often referred to, offering data and information providing insight into the condition of the region's water. The special role of drinking water sourcing from the River Ruhr supplying the industrial conurbation of the Ruhr region particularly underlines the importance of this network of waters for basic public services and infrastructure providing comprehensive facts about the protection of our natural resources and about the condition of the "waters at their doorstep". Voluntarily publishing measured data, the stakeholders of water management along the Ruhr are facing up to public discussion. Open access to the Ruhr Water Quality Report is provided via the websites of the Ruhrverband and the AWWR. In that way this popular periodical informs, documents and explains, reveals development trends, provides impetus for the public as well as professional circles and helps align water management activities in the entire river catchment area of the Ruhr.


Cover of the first Report in 1973




Cover of the Report of 2006

## NIGERIA FINALLY ESTABLISHES THE NIGERIA INTERGRATED WATER RESOURCES MANAGEMENT COMMISION (NIWRMC).

As part of the ongoing water sector reform, the Nigeria Integrated Water Resources Management Commission (NIWRMC), whose establishment was approved by the Federal Executive Council since May 2007 - the highest Federal executive governing body in the country - is yet to receive a legal backing by the National Assembly. The National Integrated Water Resources Management Act of 2008 has just passed its second reading on the floor of the Senate. The commission is body charged with the responsibility for regulation and management of water all over the country and other related matter. It is hoped that the associated problems with water management in Nigeria would soon be history. The bill also gives the body the responsibility for the economic and technical regulations of all aspect of water resources namely; exploitation and commission, construction, operation and maintenance, and tariffs of public and private water resources infrastructures.

Recently, the Federal Ministry of Agriculture and Water Resources (FMAWR) and Nigeria Integrated Water Resources Management Commission (NIWMC), with Global Water Partnership (GWP) Nigeria, swung into action and held its first national stakeholders consultative assembly on the 19th and 20th October 2009 at Abuja, to inaugurate members of the newly constituted technical and steering committees. The event drew experts and professionals from the academia, NGO's, Federal and State Government Ministries and Agencies. In his welcome/keynote address, the Executive Director of the newly established Nigeria Integrated Water Resources Management Commission, Engr. I.K. Musa welcomed members to the meeting which he said was to discuss and set necessary machinery in motion for the formation of the national technical Sub-committee on Integrated Water Resources Management as one of the main organs of the National Technical Committee on Water Resources, which is the main policy and technical advisor to National Council on Water Resources, as a component of the ongoing reforms in the water sector; and, to work out an institutional framework for incorporating the technical organ of the Global Water Partnership (Nigeria) into the structure of the proposed sub-committee. He expressed confidence that the meeting would come up with far reaching solutions towards achieving the stated objectives.

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## EU Bathing water quality results for 2009

The European Commission and the European Environment Agency have issued a joint report on bathing water quality across the EU in 2009. Overall, 96 % of coastal bathing areas and 90 % of bathing sites in rivers and lakes complied with the EU's minimum standards in 2009. The results for 2009 show a slight deterioration in bathing water quality since 2008. The actual deterioration was less than 1 % for coastal bathing waters and 3 % for inland bathing waters. Long-term results show an improvement in bathing water quality since 1990 when 80 % of coastal bathing waters and 52 % of inland bathing waters complied with the EU minimum standards.

In the UK, 97 % of all bathing water sites complied with the minimum standards in 2009 (14 sites failed out of a total of 608 bathing water sites) and 80 % of sites complied with the EU's more stringent guide values. The UK's coastal bathing waters rank 15th out of 22 member states in the EU.

**http://www.eea.europa.eu/themes/water/status-and-monitoring/state-of-bathing-water-1**

## EU member states fail to submit river basin management plans

The European Commission has warned 12 member states for failing to submit their river basin management plans. These plans are essential for achieving "good status" for all European Waters by 2015. The European Commission is also taking Belgium to the European Court of Justice for failing to transpose the 2006 Groundwater Directive to law.

**http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/685&format=HTML&aged=0&language=EN&guiLanguage=en**

## More news from EU river basin management plan implementation

http://ec.europa.eu/environment/water/index_en.htm

## SEPA sets out its priorities for the coming year

The Scottish Environment Protection Agency (SEPA) has published its corporate priorities for the coming year. The Agency's Annual Operating Plan for the 2010-2011 financial year sets out its environmental and business priorities and how the organisation is changing so it can deliver them. The Plan is organised around outcomes that are focused on (1) delivering a sustainable Scotland which enjoys the benefits of a protected and improving environment; (2) SEPA is an influential and respected authority; and (3) Scotland is is taking steps to limit climate change.
http://www.sepa.org.uk/about_us/news/2010/sepa_sets_out_its_priorities_f.aspx

## European Commission report reviews the Sewage Sludge Directive

The European Commission has published a report on the environmental, economic and social impacts of the practice of spreading sewage sludge to land. The report aims to enable the Commission to make decisions about how or whether to revise the Sewage Sludge Directive (86/278/EEC). The report comprises three parts, the first of which provides a summary of the main findings. The second part describes the main options identified for the revision of the Directive and presents a cost-benefit analysis of these options. The third part, in three Reports includes and assessment of current knowledge; a baseline scenario and analysis of risks and opportunities; and, a report on the public consultation on the first 2 parts. Five future options were assessed.

- **Option 1:** do nothing (keep the Directive as it is).
- **Option 2:** introduce certain more stringent standards (particularly for heavy metals), standards for some organics and pathogens, and more stringent requirements on the application, sampling and monitoring of sludge.
- **Option 3:** introduce more stringent standards across all substances and bans on application of sludge tosome crops.
- **Option 4:** total ban on the use of sludge on land.
- **Option 5:** repeal the Directive.

The results showed that options 2, 3 and 4 would reduce potential environmental and health impacts from spreading sewage sludge to land but could increase impacts from alternative disposal paths. Options 2 and 3 were found to be considerably less costly than option 4. Option 5 was found to be unacceptable on the basis of the precautionary principle.
http://ec.europa.eu/environment//waste/sludge/pdf/part_i_report.pdf
http://ec.europa.eu/environment//waste/sludge/pdf/part_ii_report.pdf
http://ec.europa.eu/environment//waste/sludge/pdf/part_iii_report.pdf
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31986L0278:EN:NOT

## New online service to monitor rising water levels provided by the UK Environment Agency

The Environment Agency (EA) has launched a new website that enables members of the public to monitor water levels in their local area during periods of flooding and high water, as well as periods of droughts. The EA hopes that the service will encourage householders and businesses to put their

own property-level flood defences in place if it appears they will be at risk of flooding, and to use water more wisely when water levels are particularly low. The new service will complement the EA's existing free flood alert service.
**http://www.environment-agency.gov.uk/riverlevels**

## Alternative funding sources needed for future flood defences

The UK Environment Agency (EA) has announced that future investment in flood defences will require greater contributions from communities and businesses. This reflects recommendations by Sir Michael Pitt in his review of the summer 2007 floods. The EA wishes to highlight that it is spending record levels on flood and coastal risk management (£629m for 2010-11). However, additional sources of funding will be required to protect communities, particularly as climate change increases the risk of flooding and coastal erosion.
**http://www.environment-agency.gov.uk/news/121034.aspx?month=6&year=2010&coverage=National**

## Report on the state of the UK's seas

A new report called 'Charting Progress 2' has been published by the UK Marine Monitoring and Assessment Strategy (UKMMAS) group of organisations, which includes government agencies and environmental groups. The report gives an authoritative assessment of the state of the UK's seas, based on a five-year study into how human use and other pressures, such, as climate change, are affecting the seas. Key findings from the report include:

- Sea levels have risen by 14 cm in the last century and surface temperatures have increased by one degree centigrade since the late nineteenth century.
- Many estuaries are cleaner and this has increased the diversity and number of fish species.
- Contamination by hazardous substances, such as heavy metals, has reduced in most regions and there are few or no problems relating to radioactivity, eutrophication, or algal toxins in seafood.
- Litter, particularly plastic, was found on all beaches surveyed as well as in the sea and on the seabed.
- The main pressures on the marine environment are damage to, and loss of, habitat on the seabed from fishing and the presence of physical structures.

**http://chartingprogress.defra.gov.uk/**

## Rainwater harvesting and greywater recycling systems come at the cost of greater carbon emissions

An Environment Agency report claims that, while rainwater harvesting (RWH) and greywater recycling (GWR) systems may reduce water use, in most cases they result in significantly increased carbon emissions. It calculates a typical rainwater harvesting system has a carbon intensity some 40% higher than mains water. Equivalent GWR needs twice the energy used to supply cleans mains water. It also suggests that there is scope to cut the carbon footprint of these systems through use of more efficient technologies. Storage tanks account for a large proportion of the embodied carbon footprint of RWH systems; slightly less so for greywater. Pumps make up a large proportion of rainwater and greywater embodied carbon and pumping determines net operational carbon. Individual systems vary widely but, in general, running a typical rainwater harvesting system for 30 years used the equivalent energy to that of the rest of the house for one year - or a three per cent

increase. The study's authors say their work has identified an increase in emissions but they point out the research does not consider the advantages of RWH and GWR. This should be considered alongside reductions in mains water demand and foul water volumes along with other benefits such as reduced rainwater run-off and increased "resilience" to water shortages from on-site collection and storage.
**http://publications.environment-agency.gov.uk/pdf/SCHO0610BSMQ-e-e.pdf**

## How to integrate water resources management?

The question of how to integrate water resources management has been carefully studied in a new book entitled ''Integrating Water Resources Management - Interdisciplinary Methodologies and Strategies in Practice¨'by IWA Publishing and edited by Geoffrey D. Gooch. Alistair Rieu-Clarke and Per Stålnacke.

The book provides a rich and varied picture of IWRM frameworks, the main issues at stake, the challenges and problems that face the implementation of IWRM in different parts of the world, and how one research project, STRIVER, has attempted to find solutions to existing and potential problems.

Twinning activities founded upon a problem-based approach have been performed in four case river basins:

- Tunga Bahdra (2 states in India),
- Sesan (Vietnam/Cambodia),
- Glomma (Norway),
- Tejo/Tagus (Spain/Portugal)

The problems covered are water regimes in transboundary regulated rivers; environmental flow; land and water use interaction; and pollution under the IWRM framework. The research used sub-basins of each river basin in all cases to allow more detailed studies and easier integration of all stakeholders, for transferability purposes.

Besides being a book for the scientific communcity, *Integrated Water Resources Management – Interdisciplinary Methodologies and Strategies in Practice* provides water managers, proponents of IWRM, policy-makers, stakeholders and the public, with insights into the ways in which IWRM, still more a philosophy that a finished method, might be implemented and developed in different parts of the world. The book is a combination of theoretical and empirical work, which remains unusual in the field of water management and integrated water resource management (IWRM). 34 authors – from varied disciplines, backgrounds and perspectives have contributed to the book which has been edited by Geoffrey D. Gooch, Alistair Rieu-Clarke  and Per Stålnacke.

This book has its origins in the STRIVER research project (www.striver.no). STRIVER stands for Strategy and Methodology for Improved IWRM – An Integrated Interdisciplinary Assessment in Four Twinning River Basins, and was a three-year European Commission (EC)-funded project.

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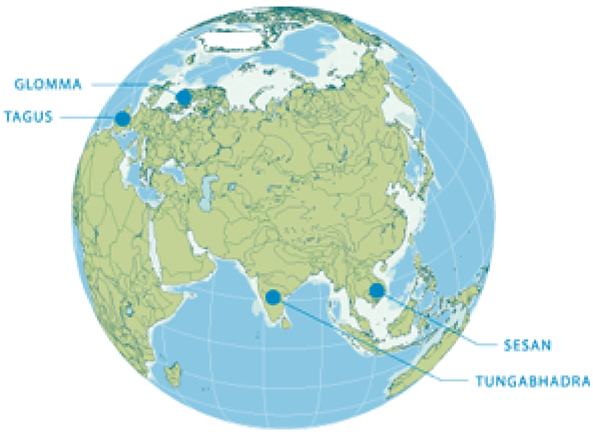
**http://www.iwapublishing.com/template.cfm?name=isbn9781843393252**

## Water at stake – how to connect science, policy and stakeholders?

Despite recent changes in water management structures and conceptual thinking there is still a lack of 'success stories', of examples of how challenges to traditional water management have been met, and how solutions have been developed to the problems of an integrated approach. One important prerequisite to successfully solve these challenges is the ability to involve stakeholders (especially the local ones 'using' the water for day-to-day activities and livelihoods). There is also a need to develop ways to improve transparency at all administrative and sectorial levels, including policy making and its implementation. This connection between science, policy and stakeholder is thoroughly presented in a new book launched entitled *'Science, Policy and Stakeholders in Water Management - An Integrated Approach to River Basin Management'* edited By Geoffrey D. Gooch and Per Stålnacke and published by Earthscan.




In the book it is claimed that the interaction of different forms of knowledge and the use and uptake of scientific results are crucial in this respect. More specifically, this book examines one of the major problems facing practitioners and scientists working with water management – how to integrate knowledge and experiences from the scientific, policy and stakeholder perspectives. This science–policy–stakeholder interface (SPSI) is examined in the book both analytically and through the description of practical experiences from river basins in Europe, India and South-East Asia. This combination of theoretical and empirical work is unusual in the field of water management and integrated water resource management (IWRM) and will hopefully contribute to the development of the SPSI for practical policy purposes.

More than 25 authors have contributed to the book which has been edited by Geoffrey D. Gooch and Per Stålnacke. This book originates in the STRIVER research project (www.striver.no). STRIVER stands for Strategy and Methodology for Improved IWRM – An Integrated Interdisciplinary Assessment in Four Twinning River Basins, and was a three-year European Commission (EC)-funded project.

The science–policy–stakeholder interface (SPSI) is examined in the book both analytically and through the description of practical experiences from river basins in Europe, India and South-East Asia. The four river basins are: Tungabhadra (India), Sesan (Vietnam and Cambodia), Glomma (Norway) and Tagus (Spain and Portugal).

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Earthscan: http://www.earthscan.co.uk/?tabid=101782

## Project WET Targets Future Stewards with "Discover a Watershed" Series

The longest free-flowing river in the continental United States is the subject of a planned booklet for children. *Discover the Yellowstone River* is a joint initiative of the nonprofit Project WET Foundation and a regional consortium of Montana conservation districts surrounding the Yellowstone River. Still in the planning and funding phase, the proposed 16-page *Discover the Yellowstone River* booklet would be distributed to 50,000 children and youth throughout the Yellowstone River watershed, providing a well-rounded, water-science-based introduction to the river and its management challenges and opportunities.

*Discover the Yellowstone River* will be the latest entry into Project WET's "Discover a Watershed" and "Kids in Discovery" (KIDs) series of educational publications and activities. Previous titles include *Discover a Watershed* books about the Florida Everglades, the Rio Grande/Rio Bravo and other major river systems and KIDs booklets covering rivers from the Missouri to the Nile. All of these Project WET books and booklets are designed for optimal use in the classroom, allowing hands-on, interactive instruction of water education topics. The series promotes awareness, appreciation, knowledge, stewardship and understanding of watershed topics and issues from an unbiased perspective.

To learn more about Project WET and its "Discover a Watershed" series, please visit the Project WET website at http://www.projectwet.org.

## Project Natura Miño-Minho

"Valorization of natural resources of the Minho/ Miño drainage basin" is a cross-border cooperation project (POCTEP) between North Portugal and Galician region of Spain. Minho/Miño (Figures 1-2) is an international river with an extension of about 300 km. Its source is in Spain (Serra de Meira, Lugo) but in the last 75 km the river defines Portugal and Spain border before reaching Atlantic Ocean near Caminha/LaGuardia.


**Figure 1** – Minho/Miño River location.

**Figure 2** – Illustrations of two different stretches of Minho/Miño River.

Main tasks proposed for Natura Miño-Minho project are the collection and integration of information about the river and a multidisciplinary analysis about its natural heritage in order to increase the knowledge about its natural resources, namely, hydric, aquatic vegetation and fauna. Expected results should allow the identification and prevention of risks and a joint management of this river basin. Laboratory of Separation and Reaction Engineering (LSRE) from Oporto University – Faculty of Engineering (FEUP) is one of the five multidisciplinary teams involved in Natura Miño-Minho Project. FEUP's activities include the physicochemical and microbiological analysis of water and sediments samples collected in different basin sites and seasons. Results so far have showed a considerable good water quality respecting to some Portuguese legal requirements. QUAL2Kw model have also been used by FEUP team to describe water quality along Minho/Miño's international stretch. Calibration of this model using the observed values allows the evaluation of discharges and tributaries impacts on the river water quality as well as the simulation of different scenarios (extreme conditions). Identification of intervention measures in order to guarantee preservation of this important resource will be addressed as a final project step.

Project team at LSRE-FEUP: Cidália Botelho (coordinator), Vítor Vilar, Sílvia Santos, Patrícia Alves and Rui Boaventura

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## Greater working with natural processes

While natural flood plains buzz with wildlife year round, man-made flood storage areas (FSAs) have always been their poor relation. Still and stagnant, the deep waters that bank up during flood events swamp any plants lying beneath and are inhospitable to wildlife. The receding floods reveal stretches of parched, dank wasteland. An imaginative new report from Halcrow, however, should ensure future FSAs harness valuable lessons from nature. Existing FSAs will also be rehabilitated to create richer habitats.

'Achieving more: operational flood storage areas and biodiversity', is one of the more inspirational outcomes of the government's Pitt Review into the floods that engulfed the UK during the saturated summer of 2007. With flood events likely to increase as a result of climate change, the review made it clear that improved flood prevention would be needed, but also recommended that the Environment Agency and its partners look at working with more natural processes in managing flood water.

Commissioned by the Environment Agency, Halcrow provided theoretical and practical guidance to ensure FSAs contribute to national biodiversity and designations targets, such as the UK biodiversity action plan. Project director Katherine Pygott and project manager Jo Cullis worked closely with renowned Open University wetlands expert David Gowing and Cranfield University's Tim Hess as consultancy advisers.

The report will be used to provide practical guidance and advice to Environment Agency project managers who are involved in both new and existing flood risk management schemes. Central to the new approach is a five-stage biodiversity potential decision key. The key proposes solutions and trade-offs between the engineering requirements of flood management and opportunities to maximise biodiversity. In practical terms, simply creating a wider flood area with reed beds and island refuges could create an enhanced, more diverse environment – allowing reed beds to flourish and layers of nutrient-rich sediment to settle. Historically, environmental inputs have often been treated as an add-on to the design process. This report sets out a way forward to ensure they are considered as an integral part of the project right from the outset with ecologists working in partnership with engineers and designers.
http://publications.environment-agency.gov.uk/pdf/GEHO0610BSOA-e-e.pdf

## Climate change And changes in SPAtial structures in Flanders: Research project (CcASPAR)

Climate change And changes in SPAtial structures in Flanders: Research project **(CcASPAR)** includes the qualitative exploration of possible planning concepts for a more adaptive approach of changes in spatial structures and implementation of spatial adaptation strategies in relation to climate change. This project includes six work packages, of which work package I will be investigated at the University of Gent. This work package will assess the spatial impact of climate change in Flanders for different climate change scenarios. Additionally, the primary effects(with a focus on the water system) and secondary effects will be geographically differentiated based on the different land uses in 2050 and 2100. Furthermore, the impacts of climate change on hydrological extremes with major focus on drought will be assessed. An integrated modeling framework for the Nete river basin will be established using local climate predictions and the WETSPA spatial hydrological model. Subsequently, a spatial adaptation strategy at the macro scale will be proposed for Flanders.

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## ENvironmental DEcision support system to select Robust operational strategies in Urban water Systems (ENDERUS)

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[2]Catalan Institut for Water Research (ICRA), Girona, Spain.

Project outline
ICRA (The Catalan Institute for Water Research) in collaboration with the Laboratory of Chemical and Environmental Engineering (LEQUIA) are working on the project "ENvironmental DEcision support system to select Robust operational strategies in Urban water Systems (ENDERUS)" that aims at developing an Environmental Decision Support System (EDSS) that addresses management problems in Urban Water Systems (UWS) including the sewer system (SS), wastewater treatment plants (WWTP), storage tanks (ST) and the receiving water bodies (RWB).

The EDSS will suggest operational strategies that will improve the overall performance of the system at the same time will contribute to guarantee the environmental standards promoted by both the European Water Framework Directive (WFD) (2000/60/EEC) and the Spanish "Plan Nacional de Calidad de las Aguas" (PNCA) 2007-2015. The EDSS will include specific knowledge about: i) the physical, chemical and biological processes taking place in the different operational units comprising the UWS, ii) the complex interactions amongst these units and finally iii) a set of upstream actions based on literature, previous experiences or simulation studies mainly focused on the protection of the receiving water.

ENDERUS will define operating strategies to achieve different objectives. These strategies will be evaluated by means of dynamic mathematical models of the integrated urban water system and by using environmental, legislation, economic and social criteria. The operating strategies will also be characterized using sensitivity analysis (to find the most sensitive parameters in the urban water system) and estimating the robustness against changes in the wastewater composition, in the sewer system configuration, and against toxic, hydraulic and pollutant shocks.

The capabilities of the proposed EDSS will be tested in the Besos River catchment (1039 $km^2$), North-east of Spain, which presents a typical Mediterranean hydrological pattern. The total population connected to the case study reaches up to 100000 inhabitants and is comprised of i) a combined sewer system , ii) Two biological nitrogen removal wastewater treatment plants (Granollers and La Garriga) which are interconnected and iii) the Congost River (with an average flow rate at the starting point of the studied area of 34500 $m^3 \cdot day^{-1}$).

*Funding:*
Spanish Ministry of Science and Innovation (Plan Nacional de I+D+I, 2008-2011)
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## Climate change impacts on river basins in semi-arid areas in India: Mitigation and adaptation measures to address current and future challenges (ClimaWater)

ClimaWater is a three year integrated project that aims to assess the climate variability and its impacts on the hydrology of the Godavari river basin, India. The main goal of the project is to prepare the base line scenarios and develop adaptation measures and tools that will help address the climate change impacts on hydrological regimes in the river basin. An important component of the project is the integration between science, management and policy through active stakeholder involvement. The project started in January 2009 to take up activities where integration could be improved and stakeholders (in particular regional water authorities in Andhra Pradesh, India) can be actively involved.

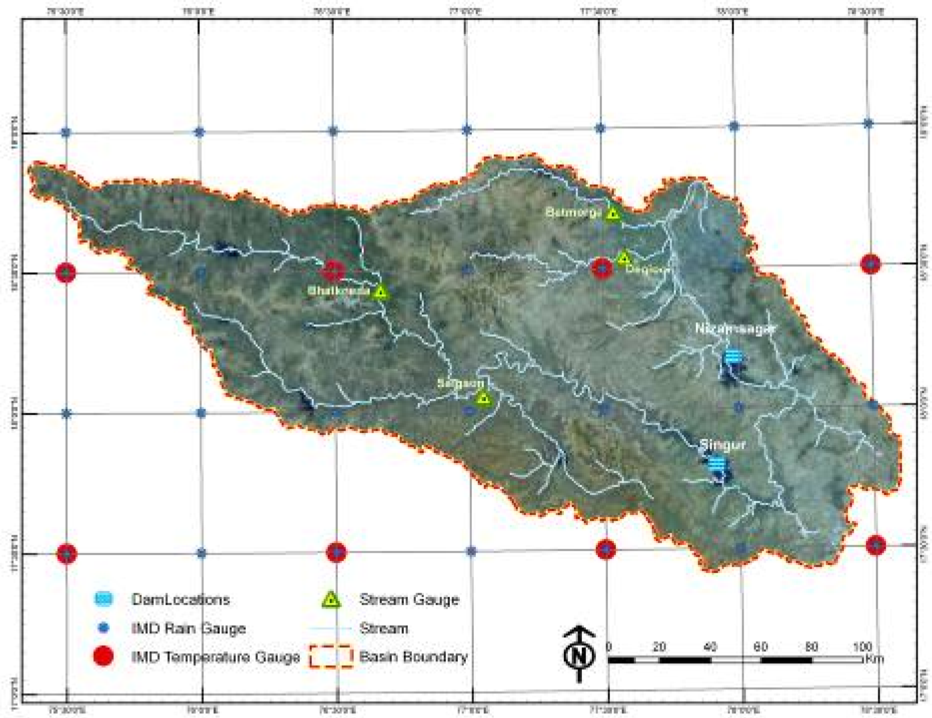
The main project objectives include:

- To identify likely impacts of climate change on water resources, e.g., hydrological flow extremes at watershed level, and changes in water quality, based on possible scenarios
- To study the socio-economic vulnerability in selected basin, society's preparedness, and the institutional and policy measures
- To assess the ongoing measures/interventions being implemented for addressing the hydrological extremes. Based on the current status, the project will develop a range of possible integrated adaptation measures
- To develop methodologies to integrate short to medium term climate change forecasts into Integrated Watershed Management systems by use of GIS and other tools/models, and aim at transferring the methodologies to other watersheds

A pilot drainage (sub-basin) of the Godavari river basin, namely the Manjira sub-basin has been selected for development of scenarios and impact assessment. The sub- basin has been mapped for the hydrological modeling and the baseline modeling results have been obtained using the historical data for the past thirty five years. The spatial and temporal assessment of water availability and flow series have been generated for the sub-basin. The water balance components have been evaluated with respect to annual and intra-annual variability.

With the basic set of the model and available data, the next step in the project is to validate the model using the observed flow data. It will be possible to evaluate the impacts of the climate change on the water resources in the larger Godavari river basin by upscaling results, with some uncertainty. The next stage of the project will focus on developing possible scenarios for adaptation. Simultaneously, water use efficiency and water quality measurements are being carried out in different irrigation systems in the Manjira sub-basin, using various methodologies. Socio-economic vulnerability assessment is done out through detailed farmers surveys (450 farmers) and at the basin level (using Ricardian modeling).

The information and results generated shall be of immense use to a very diverse set of end users ranging from policy makers to water managers to farmers and NGOs. It is also intended to disseminate this information through GIS based web application system and stakeholder workshops. More details are available at the project website (web.iitd.ac.in/~akgosain/**CLIMAWATER**/index.html). The catchment area of Manjira sub-basin is about 30914 sq km. Figure below shows the salient features of the sub-basin.





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# 1.) WATER QUALITY AND AQUATIC GEOCHEMISTRY IN THE UPPER HAN RIVER FOR THE CHINA'S MIDDLE ROUTE OF THE SOUTH TO NORTH WATER TRANSFER PROJECT

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The upper Han River (31°20′-34°10′ N, 106°-112° E; 210-3500 m *a.s.l*), a north sub-tropic basin, is situated between the northern Daba Mountains and the southern Qinling Mountains with a drainage area of approximately 95,200 $km^2$ and 925 km long. It transfers water to northern China, including the major municipalities of Beijing and Tianjin city, for various usages through China's South-to-North Water Transfer Project. Thus, water conservation in the Han River is of great importance (Zhang et al., 2009). Since 2004, we have been sampling four cruises each year for more than 40 major tributaries of the Han River, and determined its water quality including nutrients, trace elements and heavy metals, water geochemistry and associated $CO_2$ consumption, as well as landscape influences on water quality under anthropogenic activities. There are some important results as follows:

(1) Generally, water quality in the dry season is better than in the wet season due to large amounts of diffuses by rain runoff in the rainy season. The major pollutants in the River include nitrogen, chemical oxygen demand and some trace metals (Li et al., 2008b, 2009a, 2009c).

(2) Spatial and temporal pattern of nutrients are evident in the basin. Generally, high nutrient contents occur in the urban and agricultural production areas, and their seasonal variations are strongly associated with seasonal pattern of precipitation, reflecting the combined effects of diffuses and industrial effluents (Li et al., 2008a, 2009c).

(3) Similar to the results in the Changjiang system, high N:P ratios reveal that P is the limiting factor for algal production in the study area. With frequent algal blooms in the lower reaches of the Han River in recent years, proper agricultural practices should be developed and adopted to reduce nutrients into the riverine system of the upper Han River basin (Li et al., 2009c).

(4) Trace metals indicate that waters in the upper Han River are primarily polluted by Al, As, Cd, Pb, Sb and Se. Similar to the nutrients, trace metals also display significant spatial and seasonal variations with higher levels in the rainy season for most metals, and the polluted sections in terms of metals mainly concentrate in areas with intense human activities. Multivariate statistics demonstrates Al, Cd, Mn, Ni, Fe, Si and Sr controlled by natural sources, Ba, Sb, Se and V by the mixed sources of anthropogenic origins and pedogenesis, whereas As, Co, Pb, Cr and Cu primarily by anthropogenic inputs. Risk of metals on human health is also evaluated using Hazard Quotient (HQ) and carcinogenic risk, and indicates that As with HQ >1 and carcinogenic risk $>10^{-4}$, is the most important pollutant leading to non-carcinogenic and carcinogenic concerns, in particular for children (Li and Zhang, 2010a, 2010b)

(5) Water quality could be predictable by one or more landscape variables, and land use composition within an entire catchment rather than this in the riparian zone is a better predictor of nitrogen concentrations in rivers. Further, different riparian land use on water quality demonstrates that 100 meter riparian zone is essential for water quality management in the basin. Whereas, by comparing varied riparian land use on water chemistry, land use within 100 m riparian zone could explain major elements better despite varied importance of land use relating to hydrological seasonality on major elements (Li et al., 2008a, 2009b).

(6) The major ion chemistry of the upper Han River basin is mainly controlled by rock weathering with $HCO_3^-$ and $Ca^{2+}$ dominating the major ion composition in the basin. There are three major reservoirs (carbonates, silicates and agriculture/urban effluents) contributing to the dissolved load. Chemical weathering rate is approximately 53.1 t/km$^2$/yr with respective carbonate and silicate weathering rates of 47.5 t/km$^2$/yr and 5.6 t/km$^2$/yr. The $CO_2$ consumption is estimated to be $64.69\times10^9$ mol/yr and $9.69\times10^9$ mol/yr by carbonate and silicate weathering, respectively. The contribution of the anthropogenic inputs to the dissolved load is estimated to be 16.7% (Li and Zhang, 2008, 2009; Li et al., 2009d).

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## 2.) ASSESSMENT AND MITIGATION OF SOIL AND NUTRIENT LOSSES FROM A WESTERN UPLAND PEAT CATCHMENT IN IRELAND

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### 1. Introduction

Forests and forestry activities have been identified as possible diffuse sources of water pollution in upland peat areas. Since the 1950s, large areas of upland peat have been afforested in Ireland. Before the 1980s, most of the Irish peatland forests were planted without riparian buffer strips in upland areas that contain the headwaters of rivers, the majority of them salmonid. Many of these forests are now reaching harvestable age. Due to the sensitivity of the upland water and blanket peat to soil disturbance, concerns have been raised about the possible impacts of harvesting these forests on the receiving aquatic systems. In order to protect the water quality, good management practices have been introduced in Ireland, which include: (i) sizing the harvesting area using the dilution capacity in the receiving waters to limit concentrations, (ii) buffer zone development and (iii) whole-tree harvesting. However, these practices may not always be suitable for upland peat forests. Dilution sizing of the harvesting area can reduce the concentrations of the nutrients in the receiving water but will not reduce the overall nutrient load releases. Buffer zones can be efficient in removing suspended solids and particulate nutrients, but there are concerns about their effectiveness in upland blanket peat catchments - such as the Burrishoole Catchment - where: (i) most of the phosphorus (P) release can occur in soluble form during storm events, (ii) some of the buffer zone soils have low permeability and (iii) the landslopes in the catchment are steep. Whole tree harvesting removes the nutrients and base cations from the catchment, which could be essential for the next rotation crop since the fertility of the original blanket peat is very low. While the overall objectives of the project are to comprehensively assess the impact of blanket peat forest harvesting activities on water quality and to evaluate the performance and feasibility of the three different mitigation methods mentioned above, another, novel mitigation method – grass seeding – is also proposed and will be examined in this study.

### 2. Results

### 2.1 Suspended solid and nutrient releases

*2.1.1 Assessment of the impact of harvesting on water quality*

Figures 1 and 2 show one of the study catchments – Srahrevagh - that is being examined in the overall Burrishoole Catchment, and installed instrumentation. In the Srahrevagh catchment, 6 stations are instrumented to monitor the water quality in the study stream and river. The 10.5 ha area between the upstream station (US) and the downstream station (DS) was harvested in summer 2005. No significant suspended solid concentrations increase in the study stream was observed as a result of this harvesting activity. The daily mean P concentration at the DS station increased from about 6 µg $l^{-1}$ of total reactive phosphorus (TRP) during pre-clearfelling to 429 µg $l^{-1}$ one year after harvesting. The impact of harvesting on P concentrations in the study stream lasted for more than 4 years (Figure 3). In the first three years after harvesting, up to 5.15 kg $ha^{-1}$ of total reactive phosphorus (TRP) were released from the harvested catchment to the receiving water; in the second year alone, 2.3 kg $ha^{-1}$ of TRP were released. However, due to the dilution capacity of the receiving Srahrevagh River, no significant P concentration increase was observed downstream of the confluence (DSC) of the study stream and its the main river. Monitoring of the nutrient releases in the Srahrevagh study site will be continued until at least Autumn 2011 after a further 10.8 ha forest upstream of US will be harvested in September 2010.

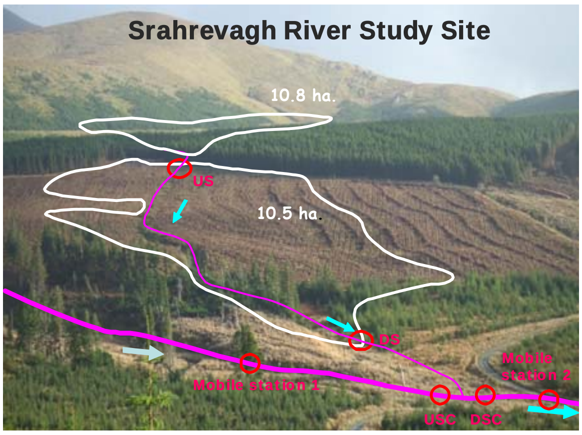

Figure 1 Srahrevagh study catchment


Figure 2 Monitoring station in the study

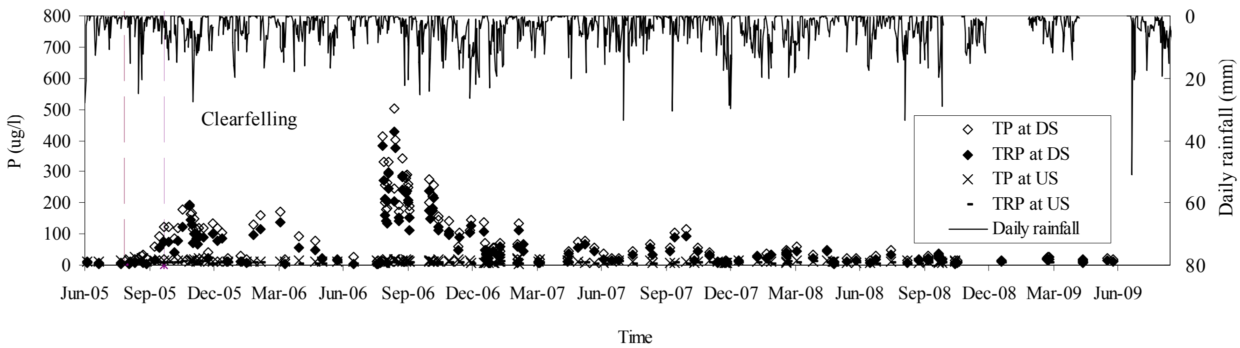

Figure 3. The daily rainfall and discharge-weighted mean TP and TRP concentrations at DS and US

*2.1.2 Identification and quantification of the possible post-harvesting nutrient sources*

The fallen needles and the harvesting residues are considered to be the main nutrient release sources. The total amount of nutrients in the fallen needles and harvesting residues will be estimated from litter bag experiments on their biomass and nutrient contents after harvesting. Six types of logging residues – fallen needles, fresh needles, small branches, big branches, small roots and big roots - were collected and weighed before they were put into small nylon mesh litter bags. A total of more than 2000 litter bags were prepared and spread in the harvested catchments and windrows (Figures 4). Every 6 months, 5 litter bags of each residue are being collected and their remaining biomass and nutrients quantified. The first set of litter bag samples was collected in May 2010 and are being analysed.

**2.2 Mitigation methods investigation**

*2.2.1 Dilution sizing of the harvesting area*

In order to limit the nutrient concentrations in receiving water, sizing the felling coupe in relation to available dilution in the main receiving waters is recommended. However, very little data are available in the literature for assessing the effectiveness of this practice in mitigating the nutrients' release. In the Srahrevagh site (Figure 1), the P concentration at DS in the study stream did not have a large impact on the P concentration in the main river, which receives water from an area of 200 ha and provides an areal upstream dilution factor estimate of about 8 with the study stream. Figure 5 shows the TRP concentrations at the DS station, DSC and USC in a storm event. When the TRP at the DS station increased from about 3 μg TRP $l^{-1}$ to 292μg TRP $l^{-1}$, the TRP concentrations at the DSC (main river) increased from about 5μg TRP $l^{-1}$ to about 11μg $TRP^{-1}$, giving a measured dilution factor of about 25, which was bigger than the estimated areal dilution factor of 8. The higher measured dilution factor could be due to higher iron, pH and alkalinity in the main Srahrevagh river. Further study on the water quality characteristics that contribute to the dilution capacity of the river is on-going.

Figure 4 Litter bags in the harvested area

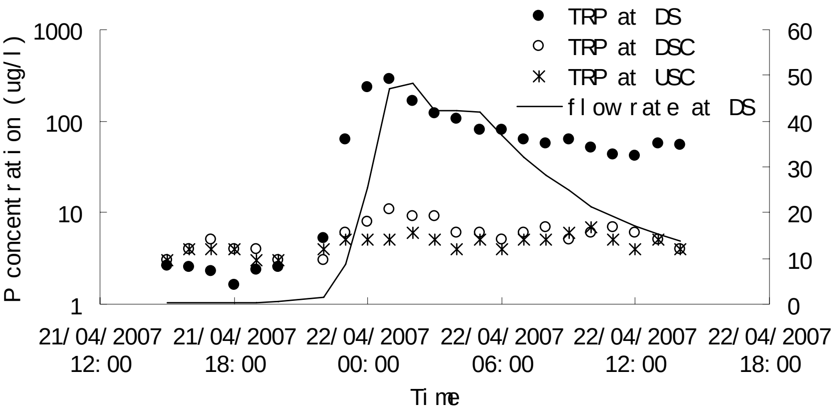


Figure 5 Total reactive phosphorus (TRP) concentrations at DS (study stream), USC (main river) and DSC (main river) with DS flow rate in a storm event

*2.2.2 Assessment of the performance of the buffer zone on nutrient release mitigation*

Buffer zones have been widely used by forestry practitioners in the management of freshwater aquatic systems. In Ireland, before the 1980s, most of the peatland forests were planted without riparian buffer strips. An option to clearfell buffer zones prior to the clearfelling of the main crop was proposed in order to minimize the possible effect of the main harvesting on water quality. The growth of vegetation is critical for the performance of a newly established buffer zone. It was found in Srahrevagh that three to four years post-clearfelling were required for the vegetation to naturally recover. In order to examine the rate of revegetation, a field trial study has been carried out to identify native grass species that could be established quickly in the blanket peat forest after harvesting. The results showed that *Holcus lanatus(Yorkshire fog grass)* and *Agrostis capillaris* (Common bent grass) germinated and established successfully over the four-month study period. In the Glennamong catchment, a 0.1 ha. buffer zone between the proposed 10 ha study site (S2 in Figure 6) and the Glennamong river (S3 in Figure 6) was clearfelled, and grass seeded in October 2009, and again in April 2010 – due to concern about the effects of the severe 2010 winter frost. The seeded grasses - *Holcus lanatus* and *Agrostis capillaries* - were well established in the buffer zone by June 2010 (Figure 7). The water from the upstream study site will be distributed to suitable buffer zone areas ( BA1, BA2 and BA3 in Figure 6) before the study site is harvested in September 2010. The performance of the buffer zone will be assessed by comparing the water quality at monitoring stations upstream and downstream of the buffer zone.

In order to further study the mechanisms of nutrient removal in the buffer zone, Slabs of soil with grass were taken from the Glennamong buffer zone and installed in 2m x 0.3m flumes. Overland flows with different TRP concentrations are being applied and the impacts of slope, grass growth and length of soil slab on the TRP removal efficiency are being studied.

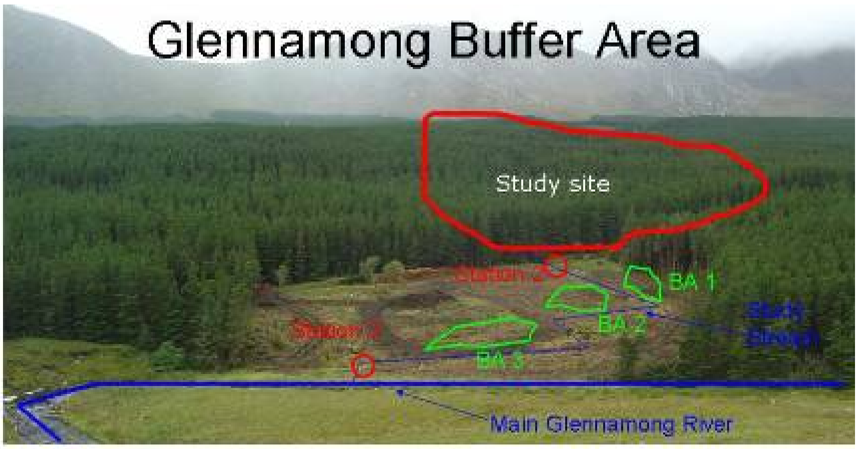


Figure 6 The established buffer zones

*2.2.3 Pilot scale investigation of grass seeding - a novel practice - on nutrient release control*

Figure 7 Growth of the seeded grasses

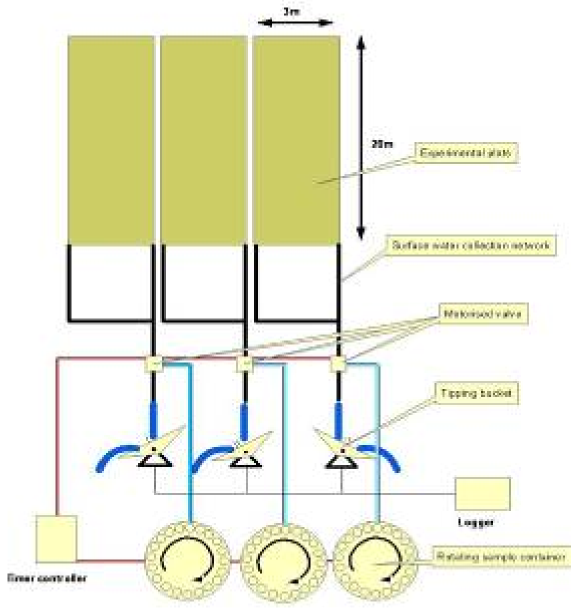


Figure 8 Plot set

Grass seeding of clearfelled areas, which is a novel forestry practice, is proposed in this study. The idea of this practice is to seed whole clearfelled areas with native and fast growing grasses immediately after harvesting. In general, it will take three to four years for the natural re-vegetation of the blanket peat forest area after harvesting, while most of the P release occurred in the first three years after harvesting in the Srahrevagh study area. By grass seeding, it is hypothesised that: (i) the fast growing seeded grasses will take up nutrients and stabilize the soil after harvesting; (ii) the nutrients stored in these grasses will be slowly released on decay, and become available for the next rotation crop, which could be critical for the growth of the new trees without additional fertilizer application; and (iii) the grasses will store carbon, reduce green house gas emissions, increase biodiversity and improve the visual aspect of the harvested catchments. In this study, a total of 15 plots of 7 m x 20 m have been set up (Figure 8) for 5 treatment studies (Table 1) with three replications. The flow rates and water quality of the runoff from these plots will be measured. The water table and soil nutrients on the units are also being measured. The effect of brash removal after harvesting on reducing the nutrient concentrations in the soil water is also being studied. In order to further study the mechanisms of the grass seeding practice on nutrient removal, slabs of soil are being taken from the forest area, inserted into the 2m x 0.3m laboratory flumes and seeded with grasses to examine the effects of rainfall simulation and surface water runoff.

Table 1 Plot scale study

| Plot No. | Treatment | |
|---|---|---|
| | Grass seeding | Brash |
| 1 | No | No |
| 2 | Yes | Yes |
| 3 | Yes | No |
| 4 | No | Yes |
| 5 | No | Brash taken away after 6 months |

**4. Conclusions**

The baseline data for assessing the effects of harvesting on water quality are being collected. Traditional mitigation methods such as dilution sizing of the harvested area, buffer zone creation and whole tree harvesting are being investigated. Grass seeding - a novel mitigation method -is proposed and its performance is being assessed. The outcomes of this project will contribute to making forestry sustainable, particularly in reducing sediment and nutrient releases from forestry activities.

*More results can be found in the following papers:*


1. *Michael Rodgers, Mark O'Connor, Mark Robinson, Markus Muller, Poole Russell and Liwen Xiao (2010). Suspended solid yield from forest harvesting on upland blanket peat. Hydrological Processes (in press)*

2. *Michael Rodgers, Mark O'Connor, Mark Gerard Healy, Connie O'Driscoll, Zaki-ul-Zaman Asam, Mika Nieminen, Poole Russell and Liwen Xiao (2010). Phosphorus release from forest harvesting on an upland blanket peat catchment. Forest ecology and management (accepted)*


For more information please visit our project website: **www.sanifac.com**

## 3.) An integrated geographic information system (GIS)-based water pollution management information system for the Three Gorges Reservoir Area, P.R. China

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### ◆ Introduction

The world-famous Three Gorges are situated on the middle reaches of the Yangtze River and have a total length of 193 km. The newly constructed Three Gorges Dam has created an immense reservoir, which has a length of 663 km, a water surface area of 1085 $km^2$, and a total reservoir capacity of 39.3 billion $m^3$. The Three Gorges Reservoir Area (TGRA) is by far the biggest of hydropower plants newly constructed in China, and its installed capacity roughly equals that of 15 nuclear power stations. There are more than 8500 commercial ships operating in the reservoir, and 17 cities and more than 1700 industrial enterprises located by the reservoir. Industrial, municipal and ship effluent has become the main pollution source for the Yangtze River and resulted in averagely 12 water pollution accidents in the TGRA every year. Water pollution accidents are a crucial problem for the TGRA and directly endanger the drinking water supply for more than 30 million people and the aquatic ecosystem.


An integrated geographic information system (GIS)-based water pollution management information system for the TGRA, called WPMS_ER_TGRA, was developed. ArcGIS Engine was used as the system development platform, and Visual Basic as the programming language. The models for hydraulic- and water-quality simulation and the generation of body-fitted coordinates were developed and programmed as a dynamically linked library file using Visual Basic, and they can be launched by other computer programs. Subsequently, the GIS-based information system was applied to the emergency water pollution management of a shipwreck releasing 10 tons of phenol into the Yangtze River during 2 hours. The results show that WPMS_ER_TGRA can assist with emergency water pollution management and simulate the transfer and diffusion of accidental pollutants in the river. Furthermore, it can quickly identify the affected area and how it will change over time within a few minutes of an accident occurring.

## ◆ Structure of the management information system

WPMS_ER_TGRA system is a new developed river pollution management information system (MIS), ArcGIS Engine, a collection of GIS software components, was used as the developing tool for new software. A professional Model Base for special calculation and analysis functions to help decision-making in river water pollution management was programmed and integrated in WPMS_ER_TGRA. The overall structure of the designed system is shown in Figure 1. The entire system includes four levels: a Data-Base system, a Model-Base system, a GIS, and a user-friendly interface.

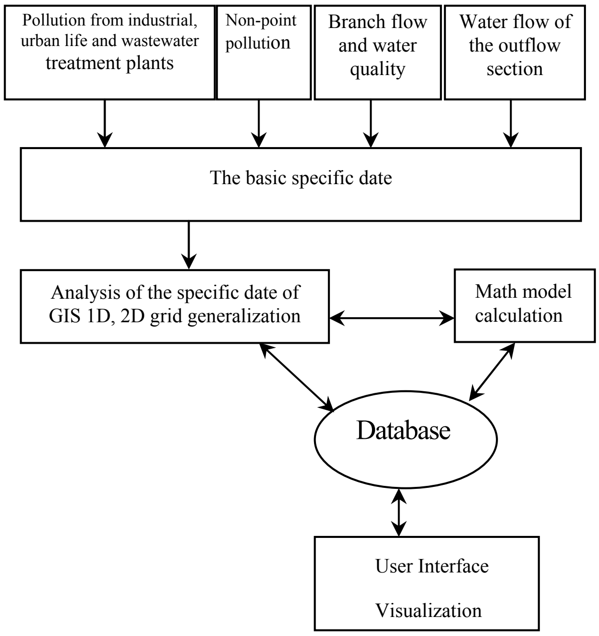



Fig. 1 The overall structure of WPMS_ER_TGRA

The interaction between different functional parts of WPMS_ER_TGRA can be described as follows. Firstly, the GIS components read digital maps from the spatial Data-Base and the user of this system can set the boundary/initial conditions for Model-Base calculation, including editing the pollution sources' information, the entrance-cross-section parameters, such as the flow rate and water quality. The boundary and initial information are deposited into a spatial-object-based database. The mathematical models subsequently read these basic data from the database, and conduct calculating tasks upon pre-set programs. The outputs such as velocity vectors and concentrations of some target pollutant parameters at different positions are stored again into the spatial-object-based database. Finally, the results are visually displayed in the user interface as thematic digital maps, which support the decision-maker with quantitative spatial-temporal modeling data.

## ◆ Application of WPMS_ER_TGRA for water pollution accident response

The WPMS_ER_TGRA system is intended to provide immediate emergency management functions for water pollution accidents. The system primarily is based on the rapid simulation of pollution migration over time. Using the GIS analysis and query functional modules, the WPMS_ER_TGRA system can show and identify the location and the affected area of the excessive pollution at various points in time, help relevant regional and sector leaders provide alerts and give them decision support. For example, the system can predict the pollution dispersion conditions after 48 hours within 10 minutes after an accident.

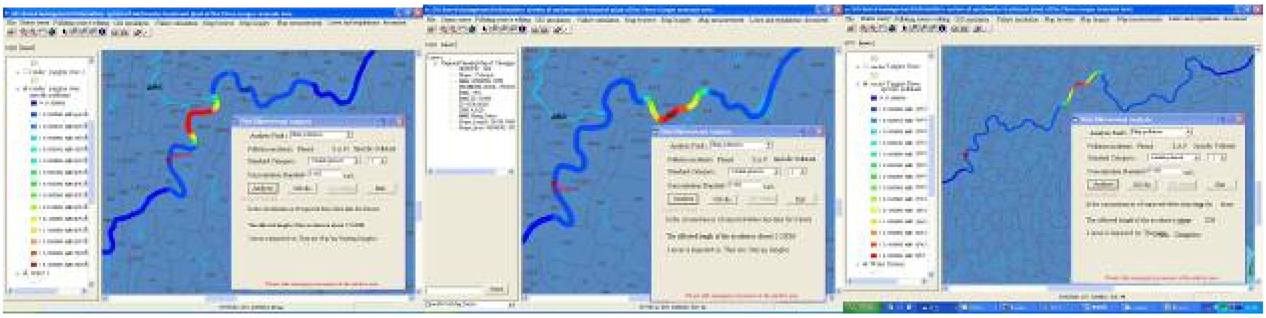
The simulation analysis of pollution incidents is mainly divided into three steps: add or edit the accident pollution source, quickly calculate the concentration field and its movement via time, analyse and visually show the simulation results. To show the emergency management function of the system, numerical analysis and visualized simulation based on an assumptive case, a ship capsized in the Dadukou district of Chongqing municipality, releasing 10 tons of phenol into the Yangtze River over the course of 2 hours, is illustrated as follows.

Add the accident pollution source

When the system user receives some basic information concerning the pollution accident, he or she shall immediately add a pollution source at the location where the accident happened, and edits the corresponding attribute data: the incident name (Capsized ship pollution), pollutant(s) (phenol), and original pollutant concentration (100000mg/L), Duration of continual emission (7200s). For the rest of the attribute data, such as the node number of the accident location in the calculation grid and the name of the affected water, the system can automatically add for the user based on GIS topology analysis module.

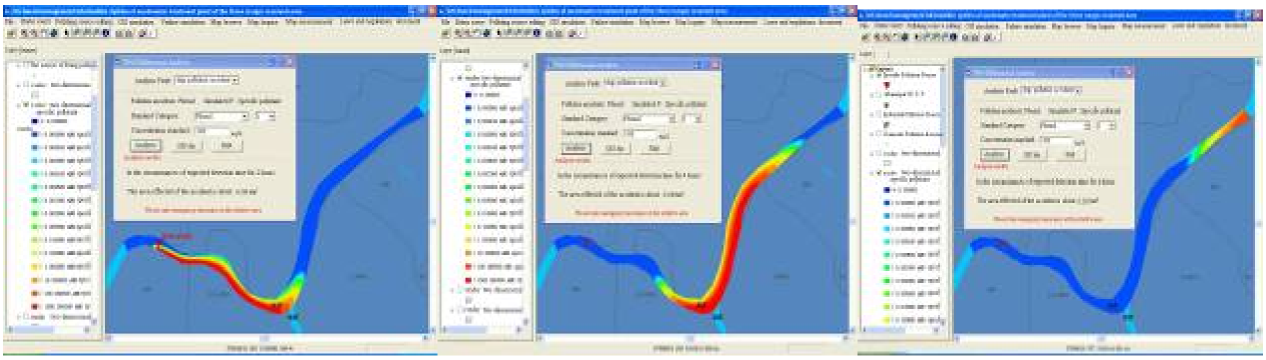
The dynamic simulation of the accidental pollution

After the basic information data of the pollution accident is stored Geodatabase, WPMS_ER_TGRA can utilize one-dimensional or two-dimensional dynamic math model as the user requirement, and quickly simulate the pollutant distribution in different time courses, based on selected hydrological condition such as “145m water level after the dam construction”. Fig. 3 shows the one-dimensional digital simulated concentration field maps for 4h, 12h, and 24h after the accident. Figure 5 shows the two-dimensional digital maps digital simulated for 2h, 4h, and 8h after the accident.



a 4h　　b 12h　　c 24h

**Fig. 4 1D digital map for over-polluted areas in the Yangtze River at various times after an**



a 2h　　b 4h　　c 8h

**Fig. 5 2D digital map for over-polluted areas in the Yangtze River at various times after an**

Analysis of the simulation results

WPMS_ER_TGRA can automatically analyze and generate statistics for the relevant city and area affected by the accident with the help of the query and analysis components of GIS. Table 3 shows the affected areas and the scope of the problem after the system analyzes the excessive pollution.

**Table 3 The area affected by pollution changes with time after an accident**

| Time after the accident | 0.5h | 1h | 2h | 4h | 8h | 12h | 24h | 48h |
|---|---|---|---|---|---|---|---|---|
| Length of excessive polluted area | 4.12 km | 7.64 km | 13.48 km | 13.6 km | 11.7 km | 13.32 km | 21.18 km | 20.88 km |
| Name of affected district | Dadukou | Dadukou, Nan-an | Dadukou, Nan-an | Nan-an, Yuzhong, Jiangbei | Nan-an, Jiangbei | Nan-an, Jiangbei | Yubei, Changshou | Fuling, Fengdu |

**Deadline for submission for contributions for the next newsletter is December 15 2010.**

International Water Association

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