Circulation

No. 100
February 2009

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Circulation is published quarterly. It is free to members of the British Hydrological Society and costs £25 to nonmembers on annual subscription.

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Circulation is indexed in *Geosystems' Hydrotitles* & *GeoArchive* and *NISC HydroROM*.

Precise but inaccurate rainfall–streamflow model parameters

a neglected uncertainty issue for discussion

In the context of PUB* and more widely, this article by **Ian Littlewood** highlights important aspects of precision and accuracy associated with the parameters of basin-scale rainfall–streamflow models.

Work published recently has shown that while a given rainfall–streamflow model parameter might be estimated (calibrated) from time series (e.g. daily time-step data) with good precision (X%), its accuracy might be two orders of magnitude worse (100X%). The problem arises when the data time-step is too coarse for the model to capture the dynamics in question. Examining the effect of data time-step on a well-known baseflow index (BFI),

*The Prediction in Ungauged Basins (PUB) Decade (2003–2012) initiative of IAHS.

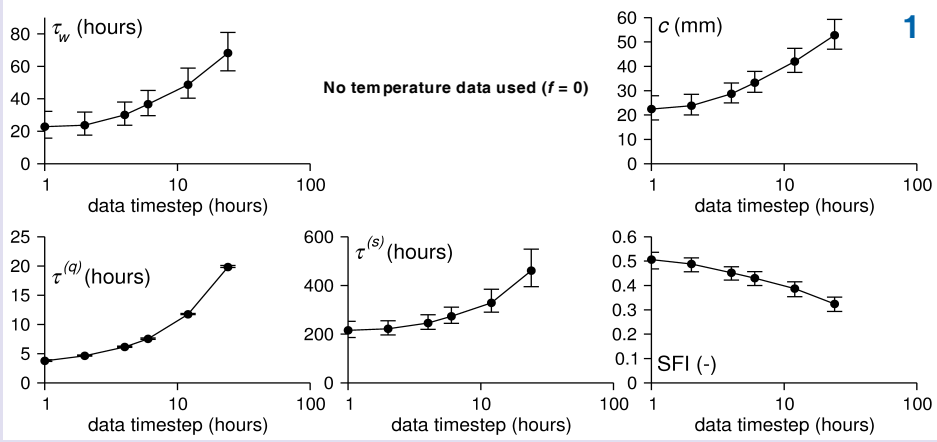
applied extensively to assist with regionalised estimation of flow statistics and hydrographs at ungauged (flow) sites, leads to the conclusion that BFI is not as good for such work as appears to have been assumed. An analogous slowflow index (SFI) is arguably superior to BFI for regionalisation work, especially when normalised to be essentially independent of data time-step.

A commonly-used IHACRES model structure has the following six parameters [dimensions shown thus]; τ_w [T], f [$^oC^{-1}$], c [L], $\tau^{(q)}$ [T], $\tau^{(s)}$ [T] and $\upsilon^{(s)}$ [-]. The nature of these model parameters and how they are calibrated are covered in the research literature — see references given later. Details are therefore omitted here but note that (a) the superscripts q and s denote dominant quick- and slow-response components of streamflow, (b) $\tau^{(q)}$ is a decay response time associated with the quickflow component and (c) $\upsilon^{(s)}$ is a slowflow index (SFI) analogous to baseflow index (BFI). (Later in this article BFI and SFI are compared for the 10.6 km^2 Wye at Cefn Brwyn.) When air temperature data are not used for model calibration, parameter f plays no part in the model (f set to zero has this effect). Figure 1 shows the remaining five IHACRES parameters for the Wye at Cefn Brwyn when the model was calibrated using rainfall and streamflow at time-steps between and including hourly and daily[1].

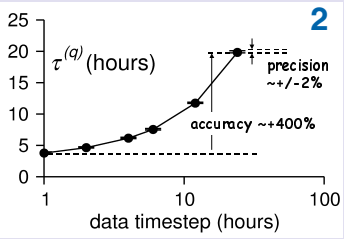
The indicative 95% confidence bands shown in Fig. 1 suggest that the parameters calibrated using hourly data are significantly different to those calibrated using daily data. Furthermore, each model parameter reaches, or approaches, a stable value as data time-step decreases to hourly. These stable values are essentially independent of data time-step and therefore probably better characterise catchment-scale rainfall–streamflow dynamic behaviour than corresponding values calibrated using larger data time-steps.

The value of a given Cefn Brwyn model parameter calibrated using hourly data provides a reference against which the accuracy associated with the value of that parameter when calibrated using larger data time-steps can be assessed, as illustrated for parameter $\tau^{(q)}$ (daily) in Fig. 2.

For the Wye at Cefn Brwyn, accuracies of model parameters calibrated using daily time-step data are +192% (τ_w), +132% (c), +426% ($\tau^{(q)}$), +111% ($\tau^{(s)}$) and –18 percentage points (SFI). The uncertainty in a model parameter is some combination of its precision and accuracy. Interestingly in this case, amongst the parameters



IHACRES calibrated model parameters for the Wye at Cefn Brwyn, 6 December 1987 to 2 July 1988, against data time-step (from Littlewood and Croke, 2008)



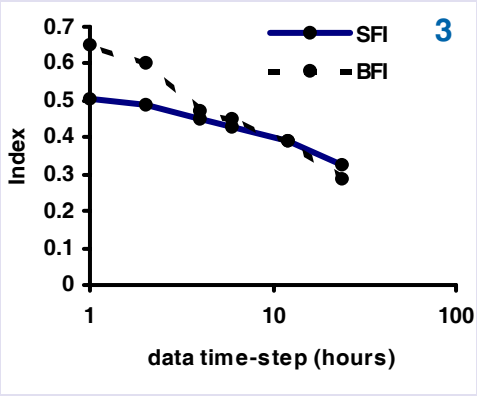
Precision and accuracy for Wye at Cefn Brwyn model parameter $\tau^{((q)}$

calibrated using daily data, $\tau^{(q)}$ has the worst accuracy (+426%) but the best precision (about +/– 2%, Fig. 2). Assuming that $\tau^{(q)}$ of about 4 hours is correct (an assumption that warrants further inspection but is reasonable for this short article), a daily time-step is clearly too large to capture that dynamic. The other four model parameters also exhibit increasingly poorer accuracy as data time-step increases, albeit to a lesser degree than for $\tau^{(q)}$. For example, assuming that values of τ_w and $\tau^{(s)}$ of about 23 hours and 220 hours respectively (Fig. 1) are correct, the accuracy associated with those parameters derived from daily data is better than for $\tau^{(q)}$ (but still > 100%). Given the model structure considered here (there are other IHACRES model structures) and how its parameters are calibrated, the non-time dimensioned parameters (*c* and SFI) are obliged to exhibit similar sensitivity to data time-step.

So, a model parameter estimated with good or fair precision using an inappropriately large data time-step can have poor accuracy and therefore be very uncertain. The distinction between precision and accuracy associated with rainfall–streamflow model parameters has received insufficient attention in the literature. In the context of PUB, poor accuracy in model parameters will account for part of the typically poor performance of many published model parameter regionalisation schemes used for estimating flow statistics (mean, percentile flows, etc.) or time series (continuous hydrographs) at ungauged (flow) sites.

For the Wye at Cefn Brwyn, non-IHACRES rainfall–streamflow models and modelling methodologies will also exhibit model parameter sensitivity to data time-step. Different catchments, exhibiting different streamflow dynamics, will require rainfall–streamflow modelling at different data time-steps (whatever model is used) to quantify accurately the dynamic behaviour of each basin. Model parameter and flow statistic regionalisation studies to date (those that employ daily data for all gauged basins – including those that have used IHACRES), and even reference books and relevant encyclopaedia chapters, have not adequately recognised, discussed or dealt with the data time-step sensitivity modelling issue. Data-based mechanistic (DBM) modelling, of which IHACRES can be considered to be a special case, shows considerable promise for model parameter regionalisation studies, e.g. for continuous-time model parameter estimation from discrete-time data[2,3].

Another example demonstrates further the extent to which the data time-step issue has not been sufficiently recognised[4]. A well-known baseflow index (BFI), derived solely from daily flow data, is a key variable in several regionalisation schemes to assist with estimating flows at ungauged sites. BFIs for about 1000 UK catchments have been published as "a measure of the proportion of the river runoff that derives from stored sources"[5]. Fig. 3 compares BFI and SFI, calculated or calibrated using the same Wye at Cefn Brwyn 1-, 2-, 4-,



BFI and SFI for the Wye at Cefn Brwyn, 6 December 1987 to 2 July 1988, against data time-step (from Littlewood 2008)

6-, 12- and 24-hourly datasets. As noted already (Fig. 1), SFI approaches a stable value as data time-step decreases to hourly, having increased by about 18 percentage points from its daily value. This stable value is denoted SFI*. BFI, on the other hand (Fig. 3), shows no indication of reaching a stable value as data time-step decreases, and it changes with data time-step by about 36 percentage points, or by about twice as much as SFI. SFI* is therefore superior to BFI as a characterisation of catchment-scale behaviour.

It is well known that BFI derived from daily flow data for a given UK catchment typically does not change much from year to year. This has persuaded some that it is a good characterisation of basin-scale behaviour for comparing catchments quantitatively. BFI (daily data) has often been employed as an independent variable in model parameter regionalisation equations based on statistical analysis of data from many gauged basins. However, Fig. 3 shows that BFI calculated using data at selected time-steps between hourly and daily is a rather poor statistic for characterising the Wye at Cefn Brwyn. Indeed, BFI can, by definition, vary only between 0% and 100% but for Cefn Brwyn it changes by about 36 percentage points depending on whether the data time-step used is hourly or daily. BFI, therefore, is of quite limited utility quantitatively in this case.

SFI normalised to be essentially time-step-independent (SFI*) is likely to be a far more useful statistic than BFI for comparing catchments quantitatively. BFI is no more than a time series shape factor, and any physical meaning ascribed to it (see above) is valid only on a rather coarse scale. SFI* is a result of linking rainfall and streamflow dynamically and therefore merits physical interpretation on a finer scale. SFI* is likely to be more strongly correlated with physical catchment descriptors than BFI (daily), and therefore should be a better independent variable in model parameter regionalisation equations, leading to a reduction in predictive uncertainty at ungauged sites (a major objective of PUB).

It is not surprising that calibrated rainfall–streamflow model parameters are sensitive to data time-step, because the information content of hydrometeorological time series (especially during high-intensity, short-duration, events) decreases as data time-step increases. Quite a lot has been written about uncertainty in rainfall–streamflow model parameters but it has been concerned largely with precision. Accuracy has been largely neglected, even though it can be by far the largest component of uncertainty. Quite a lot has also been written about 'scaling' in hydrology, mostly with respect to spatial scaling and not tackling head-on the modelling data time-step sensitivity issue outlined here.

Suggestions for further work

Suggestion 1: Non-IHACRES models (and modelling methodologies) can be applied to the same Wye at Cefn Brwyn datasets, in the way outlined here, to assess the sensitivity of their model parameters to data time-step and whether they also (as for IHACRES) reach or approach useful stable values as data time-step decreases.

Suggestion 2: IHACRES and other models can be applied to the Wye at Cefn Brwyn and other catchments, using new 1-, 2-, …, 24-hr datasets.

To facilitate take-up of the first suggestion, the Wye at Cefn Brwyn 1-, 2-, …, 24-hourly datasets used to obtain Fig. 1 can be downloaded (free of charge) from the website of the PUB Top-Down modelling Working Group :http://tdwg.catchment.org/). Those who follow-up either suggestion (or both) may, of course, submit papers to whichever journal they choose (but the author can recommend one in particular!). The TDWG would welcome being kept informed of who does what on this topic. The suggestions for further work made above are not restrictive. Indeed, the PUB/TDWG initiative TRUMPER (Towards Reducing Uncertainty in rainfall-streamflow Model Parameter Regionalisation, see http://tdwg.catchment.org/ - projects) provides researchers interested in this topic with a forum for dialogue and dataset-sharing. Do join in.

Ian Littlewood

Acknowledgements
Thanks to members of the TDWG, particularly Barry Croke (Australian National University), David Post (CSIRO) and Peter Young (Lancaster University). The views expressed are those of the author.

[1] Littlewood, I.G. and Croke, B.F.W. (2008). Data time-step dependency of conceptual rainfall-streamflow model parameters: an empirical study with implications for regionalisation. *Hydrological Sciences Journal*, **53**(4), 685–695.

[2] Young, P.C. and Romanowicz, R. (2004). PUB and data-based mechanistic modelling: the importance of parsimonious continuous-time models. *Conference Proceedings of the International Environmental Modelling and Software Society*, Volume 3, 1141–1146.

[3] Young, P.C. and Garnier, H. (2006). Identification and estimation of continuous-time, data-based mechanistic (DBM) models for environmental systems. *Environmental Modelling and Software*, **21**, 1055–1072.

[4] Littlewood, I.G. (2008). Characterisation of river flow regimes for environmental and engineering hydrology: unit hydrographs for rainfall-streamflow modelling. *Folia Geographica series Geographica-Physica*, **XXXIX**, 5–36. (see also http://www.geo.uj.edu.pl/foliageographica/spis2.php)

[5] NERC (2003). *Hydrological Data UK: Hydrometric Register and Statistics 1996–2000*. 208pp.

President's piece

As we all enter a period of what is likely to be a prolonged period of economic difficulty, it is pleasing to be able to report that BHS is in rude financial health, and that our membership remains solidly above the 1000 mark. This is tribute to the members (and of course your hardworking committee) who continue to organise a wide ranging programme of national and regional meetings which are obviously relevant, and of interest to members, as you keep attending. However, as I mentioned in my last PP, a lot of non-members also attend such meetings, although they must pay additional registration fees. Personally, I have no objection to non-members attending our meetings as hopefully they will be inspired to join in order to receive the benefits of membership. However, as a member reading this edition of *Circulation*, why not pass it on to non-member colleagues when you have finished reading it — it may just encourage a few more to join and hence maintain the society's sound financial base.

The society continues to organise a very good programme of national and regional meetings (see the website and the Diary in this edition of *Circulation*), but we are always looking for suggestions for new topics (preferably backed up by an offer to either organise and host such a meeting, or at least assist the main or regional committee with these activities). If you have an idea of a topic for a meeting, then please email either myself (frank.farquharson@btinternet.com) or the Hon Secretary, Claire Walsh (claire.walsh@newcastle.ac.uk) with suggestions.

It is also very pleasing to see that the society's new journal *Hydrology Research* is flourishing (see page 16, and we congratulate the joint Editor, Ian Littlewood, on his efforts. The final issue of 2008, contains two papers jointly-authored by BHS members, one by Sarah Dunn, a former committee member, and another by John Sutcliffe, an Honorary BHS member, two other BHS members and myself. Do please try to contribute to this journal that you as members suggested you wanted in a questionnaire a few years ago.

In the last edition of *Circulation* I described the new Guide to Professional Development and Training for Hydrologists, which is now available on the website at http://www.hydrology.org.uk/BHS-PDT-Guide-v1.1Sept08.pdf. I asked anyone interested in 'test driving' the new guide to get in touch with me and I'm pleased to say that I am in contact with at least one individual who is trying to go for CEng through the Institution of Civil Engineers. If any others out there are seeking help and guidance, please feel free to contact me, as I accept that the current draft guide might best be supported by assistance from myself as 'editor in chief' of the Guide, which still needs some polishing.

What are the current hydrological issues of interest to members? Well the Pitt Review and interest in floods continues to be fairly high on the government agenda, with Defra

having published the "*Government's response to Sir Michael Pitt's review of the summer 2007 floods*" in December last year and with a draft Floods & Water Bill to be published around April for public consultation (see also page 16). In both cases, much of the emphasis is on institutional matters and over which agency has responsibility for particular activities and where funding is to come from but, as hydrologists, we must continue to ensure that technical issues are appropriately addressed by government.

One item of interest relates to funding for flood risk. The current comprehensive spending review will increase such central government funding through Grant-in-Aid by over 20% from 2008–09 by 20010–11 to almost £679 million, which is to be welcomed. Flood funding also comes through a local levy out of Council taxes but this amounts to only the small amount of some £27 million nationally, of which £10 million is raised in the Thames basin alone. Even in the Thames basin, therefore, the Council Tax levy represents less than 1 pence *per capita* contribution, or perhaps 4 to 6 pence per household. Considering how much each of us pay in Council Tax annually (ranging from £900 to £2700 in my area of Oxfordshire), allocating less than 10 p of this on flood defence seems rather miserly. Perhaps we should be lobbying government for greater expenditure. Given that the summer 2007 floods caused over £3 billion damage, which we all pay for anyway through house contents insurance premiums, perhaps more should be spent on flood defences such that insurance premiums might be lower?

We must continue to express our views to government, generally through Defra, to ensure that adequate research and development funds are available to enable the technical challenges of improved flood warning and flood defence design are met. One key new research area following the summer 2007 floods is that on forecasting flash flooding, or surface water flooding, predominantly in urban areas. A joint Met Office EA project is currently under way on this topic, and we as hydrologists must look critically at the outcomes when available, as it may well be that meteorologists are not necessarily the best placed specialists to undertake such work without hydrological (and hydraulic) support. You may detect an element of scepticism on my part here, and this is due to my experiences following the Boscastle floods, when Met Office staff, supported unfortunately by a colleague at CEH, purported to have "solved the problem of what caused the Boscastle flood using Met Office 'products' and CEH modelling", yet who significantly underestimated the magnitude of the flood. I believe there is still a need for researchers to be monitored by experienced practitioners in many such cases, hence my reserves over the current stormwater flooding exercise — I hope I am wrong !

Another ongoing issue is that of where the water is to come from for the Government's planned 200 000 extra houses per year. Whilst there is as yet no physical shortage of water in the UK, as the population continues to rise beyond 60 million, combined with demand for increased house numbers, water scarcity must be a problem that hydrologists must help to address, particularly under a changing climate. With summers, particularly in the south and east, expected to become very significantly drier by the middle of the century, there is a need for good hydrological downscaling of global and regional climate change scenarios to assess their impacts, and the latest UK climate impacts guidance from UKCIP09 (which was supposed to be published last year as UKCIP08!) is eagerly awaited.

So to conclude, the society continues to flourish and offers a wide range of technical meetings to members. The society can now lay claim to a half-share in the *Hydrology Research* journal. Despite the current credit crunch, the demand for hydrological advice remains high, with many issues faced by Government requiring sound technical advice and information from hydrologists. There are still good career prospects for hydrologists, in the widest sense, as our society is a very 'broad church', so even in this year of economic gloom and doom, be optimistic and look forward to continuing to address a wide range of environmental challenges over the coming year !

Frank Farquharson
President

New members

Siti Nurhidayu.....Lancaster University
John Aldrick.....Environment Agency, Leeds
Babatunde Abiodun Anifowose...BirminghamUniversity
Robin Drayton Ayre.....Mouchel, Bradford
Joanna Bolding.....Kent
Rene Capell.....Northern Rivers Institute, Aberdeen
Stephen Carr.....Midlothian
Hannah Clilverd.....University College London
Andrew Jason Collier.....JBA Associates Ltd, Newcastle
Marc Conner.....Halcrow, Wilmslow
Kathryn Connolly.....Atkins Ltd, Peterborough
Caro Anne Cooke.....FRS Freshwater Laboratory, Pitlochry
Andrew Cox.....Atkins, Bristol
Charlotte Crisp.....Northampton University
Georges Dussart.....University of Kent, Canterbury
Philip Emonson.....JBA consulting, Oxford
Catherine Farmer.....Environment Agency, Warrington
Emily Louise Gordon....Environment Agency, Wallingford
Jane Grant.....Aberdeen University
Hywel Meilyr Griffiths..University of Wales, Aberystwyth
Rachel Elizabeth Hamilton.....Birmingham University
Yi He.....Kings College London
Andrew Mark Heath-Brown.....Fabel Mounsell, Leeds
Jennifer Higgs.....Capita Symonds Ltd, Grinstead
Thea Johnstone.....Environment Agency, Warrington
John Keery.....Lancaster University, Warrington
Adrian Laycock.....Independent consultant, Oban, Argyll
Suzanne Maas.....Jacobs, Manchester
Richard Francis McKey.....Environment Agency, Exeter
Carol McSweeney.....Oxford University
Temitope Dare Oyedotuh.....Leeds University
Nathalie Patureau.....Newcastle University
Karen Michelle Potter Liverpool University
Lucy-Ann Proctor-Nicholls.....Haycock Associates, Pershore, Worcs
Rakesh Ranjan.....Halcrow Group Ltd, Worcester
Sion Edwards Roberts.....RSK Geoconsult Ltd, Frodsham, Cheshire
Juan Pablo Rodriguez Sanchez..Imperial College London
Megan Rogers.....Atkins, Peterborough
Cathleen Ryan.....British Waterways, Gloucester
Keelan Serjeant.....Enzygo Ltd, Plymouth
Yogendra Babu Sharma.....Oxford University
Mike Streetly.....ESI, Shrewsbury
Robert Sweet.....Scott Wilson Ltd, Plymouth
Lucy Taylor.....Environment Agency, Warrington
Matthew James Travis.....Enzygo Ltd, Sheffield
Sean Turner.....Renfrewshire
Fredrik Wetterhall.....Kings College London
Thomas Worrall.....Loughborough University



Centre for Ecology & Hydrology publishes Delivery Plan, 2008–2013

The Centre for Ecology and Hydrology, who together with ICE, are the founder supporting bodies for BHS, has launched a new Delivery Plan. This outlines how CEH will address the scientific challenges and organisational goals set out in their Science Strategy for 2008-2013. The Plan is a working document and will evolve as CEH continues to remain responsive to stakeholders' scientific requirements and research trends within the wider academic community. The document and the companion '*Integrated Science for Our Changing World*', CEH's Science Strategy 2008–2013, may be downloaded from http://www.ceh.ac.uk/science/corpstrat.html

The grass is always greener…or is it? Maybe just a little….

Nutrient Sensitive Zones-Lakes and Waterways
Rotorua Lakes 2008 Symposium, August 2008

I would firstly like to thank BHS for making a contribution through the travel grant fund for me to attend this meeting hosted by the Lakes Water Quality Society Inc. and The Royal Society of New Zealand, Rotorua Branch. I arrived in New Zealand with the perception that environmental management in the Antipodes was light years ahead of Europe in terms of legislation and research. I was intrigued to discover how this had been achieved and to take the lessons learnt back to the Proactive team at Newcastle University. The *Proactive* team, led by Drs **Paul Quinn** and **David Rimmer**, are interested in water quality and quantity issues, mitigation and management methods to protect surface and groundwater systems.

The conference was fantastic, with a spectrum of speakers from all aspects of managing diffuse pollution, including the **Minister of the Environment**, **Hon. Trevor Mallard** and other politicians, regulatory authorities, scientists, economists and land managers including farmers. The keynote speaker was **Dr Erik Jeppesen** from the National Environmental Research Institute in Denmark. He discussed the effectiveness of European policy measures, including **The Water Framework Directive**, on reducing the nutrient status of waters in Denmark. Erik was a captivating speaker and was quite controversial in an after dinner speech by saying it was a nonsense to think that those seeking radical reductions of nutrient inputs could sit down and reach an amicable agreement with polluters and likened them to the hen and the fox: it's all fine until the fox gets hungry! I wasn't clear at first who he was describing as the fox and who was the hen but that would clearly depend on your point of view!

Dr Stewart Ledgard from AgResearch who is probably best known for the OVERSEER nutrient budget model presented a fascinating talk on what I consider rather unusual mitigation options such as application of diuretics to cows and application of nitrification inhibitors to soil. The diuretics' research showed an increase in water consumption by the cows, with more urination with lower N concentrations, which resulted in a greater spread of urinary-N and reduced the 'urine patches' or hotspots. Stewart showed the nitrification inhibitor research by Di & Cameron 2002, from Lincoln University where DCD inhibits the conversion of ammonium into nitrate which is easily leached. They showed a 40–80% reduction in N leaching and N_2O emissions when DCD was spread onto cow urine in lysimeter studies. Another study on a dairy farm with higher rainfall reported a 20% reduction in nitrate leaching using DCD inhibitor.

Other notable speakers were **Dr Kit Rutherford** (NIWA), **Dr Dan Marsh** (Waikato University) and **Gilbert Clifford** (Federated Farmers Union). Kit bravely pointed out that mitigation was not going to work everywhere and that, "we can't always have our cake and eat it!", Kit presented 'Rolls Royce' buffer strips which were truly inspirational although costly. Dan discussed the economics of diffuse pollution and mitigation which demonstrated a very clear outcome such that low intensity farms profits will be hit the hardest without much reduction in nutrient discharges whereas high intensity farmers had lower abatement costs with higher reduction in nutrient losses. Even though this is fairly obvious to most, it helps provide transparency to land managers on the apparent unfairness of policy targeting intensive farming. Gilbert, the only farmer who presented at the conference gave a

passionate talk and demonstrated that farmers/land managers want to protect the environment for their future children but still want to use it as a resource. My impression was that Gilbert, like many UK farmers, felt demonised by regulatory authorities and scientists as a 'polluter' and very much wanted to move away from the, "who is to blame?" culture to "what are the solutions?" Gilbert has taken part in some trials using water cress, straw bales and grass buffers to capture his nutrients before they escaped, with some success.

I learnt many things from my trip to New Zealand (and Australia…I visited **Dr Chris Carrol** (in the **Fitzroy UNESCO HELP basin**) and attended the Fitzroy Flood Forum organised by Fitzroy Basin Association in Rockhampton prior to the above conference.) We are all grappling with the same issues in slightly different ways but with one common theme…people. It's quite a philosophical discovery but it came as an unexpected surprise, to travel all that way and discover the stumbling blocks to progress in achieving sustainable water quantity and quality management is the interaction between people. I strongly believe that we all want to be heard but it is just as important to listen.

I think the most inspiring part of my adventure in the Antipodes was that in both the Fitzroy (Australia) and around the Rotorua and Taupo lakes, everyone felt empowered to make a difference and there was a real sense of community to find a solution. I hope I have had a glimpse into the future of the UK!

Jennine Jonczyk
Newcastle University

River Flow Conference

Cesme, Turkey, September 2008

I was fortunate enough to have my paper "The influence of plant morphology on velocity and turbulence structure" accepted at this conference. I am also very grateful for the support that was provided by BHS. This report outlines some of the aspects I personally found most useful and interesting, presented in the context of my research on coastal wetlands and their effects on flow dynamics for my PhD at the Hydro-environmental Research Centre at the Cardiff School of Engineering. To emphasise its significance, a publication by the Environment Agency estimates that having an 80-metre stretch of saltmarsh fronting a sea wall can reduce its costs from £5000 per metre to £400 per metre. This is due to a number of mechanisms, such as flow velocity reductions and wave energy attenuation. Thus, I was largely interested in vegetated flows, and the characterisation and quantification of the associated drag forces.

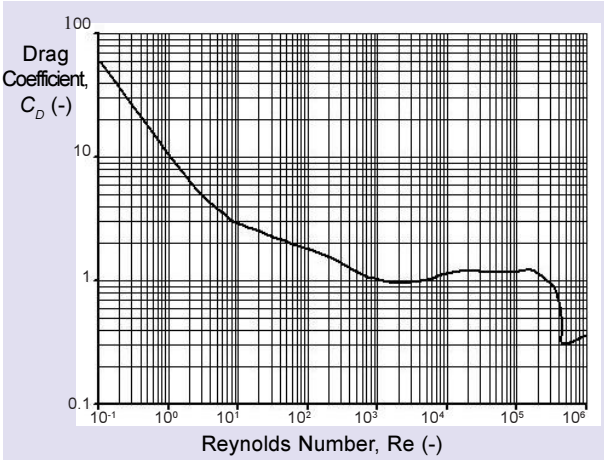
A number of papers were presented at the conference dealing with vegetated flows, the characterisation of vegetation resistance, and the measurement of velocity and turbulence profiles in vegetated flows. As this is a relatively new area of research, numerous researchers have proposed quantitative relationships to describe physical processes and, quite often, these contradict earlier suggestions by previous authors. Although such relationships have been incorporated into numerical models to predict the hydrodynamic characteristics of an aqueous vegetated environment with reasonable accuracy, there remains a significant amount of research to be conducted before the physical processes behind these relationships can be better understood. But quite often, natural environments can be difficult to model accurately where the vegetation cannot be quantified easily, which is a common difficulty when dealing with a natural heterogeneous material.

I engaged in a number of discussions with engineers and researchers working in research-based organisations that investigate various design aspects for current engineering projects. Such organisations that had representatives at the conference

include HR Wallingford and Deltares. Through such discussions, it occurred to me that for research students heavily involved in a specific subject area, it is easy to overlook the application of their work. Researchers working on projects linked to industry in such organisations are constantly concerned with the final outcome of their work as they are often under considerable pressure to meet numerous targets by certain deadlines. Such discussions encouraged me to take a step back and reflect on my work, and where it falls into the bigger picture, the limitations of my results and how they can be applied by others, or at least, the further work needed to be undertaken by others before my findings can be adapted to environmental problems linked to coastal wetlands.

Through discussions related to my work, and to vegetated flows in general, I would like to clarify a common misconception amongst engineers that I had to come to terms with early on in my work. It is widely agreed that to represent the resistance due to vegetation, a drag force approach would be most suitable, as opposed to a bed roughness term such as a Manning's roughness coefficient, which assumes that the bed roughness does not protrude into the flow. Through the drag force term, the resistance caused by the vegetation is treated as a physical obstruction to the flow, and the term contains a drag coefficient (C_D) which is characteristic of the vegetation characteristics. These can include material properties (e.g. stiffness), stem density and the submergence level of the vegetation. The value of the drag coefficient is likely to be required as an input parameter in hydrodynamic numerical models with a subroutine dealing with vegetation resistance.

The misconception is that a value of unity is to be expected under all circumstances and if any other value is obtained, then an error has likely occurred, either in recording measurements or in the calculation method. This certainly seemed to be the impression portrayed by another presentation, and was implied in one of the questions presented to me following my presentation. Having worked closely with drag forces and the associated coefficients, I feel it would be useful, therefore, to clarify a couple of points. Firstly, consider the Drag Coefficient – Reynolds Number curve (the C_D – Re curve) for a single cylinder as presented in many of the popular fluid mechanics textbooks (see figure below).



The drag coefficient is approximately equal to unity for Reynolds numbers between 10^3 and 3×10^5 which corresponds to a turbulent flow. Flows characterised by this range of Reynolds numbers can be found in the natural environment. However, for certain problems, such as within coastal wetlands, where flow velocities can be extremely low (in the order of a few centimetres per second) such that the Reynolds number is considerably lower, then frictional drag along the surface of the obstructing objects becomes much more significant as indicated by a much higher drag coefficient. It is therefore vital to consider the range of Reynolds numbers when comparing the drag coefficients from data sets taken from different studies (this was overlooked by one presenter who had difficulty explaining the significant difference in values).

Secondly, the curve presented corresponds to a single cylinder, and does not apply to an array of cylinders, or a vegetation canopy, where the wakes of cylinders can shelter downstream cylinders resulting in lower drag coefficients. Furthermore, if the vegetation is flexible, then oscillation of the stems can lead to augmentation of the

wakes causing even greater wake sheltering. Thus, the problem becomes significantly more complicated when considering vegetation canopies. Note also that the plants within a vegetation canopy are often assumed to be cylindrical in shape though this may not be the case, and the curve presented above is specifically for a uniform cylinder. In fact, when this curve is presented in text books, it is often accompanied by the curve for a sphere, which varies significantly, demonstrating that the shape of the curve is affected by the morphology of the obstruction.

As I consider the applicability of my work following discussions with industrially-minded researchers, the points outlined above emphasise the limitations of my work. For my findings to be applied directly to a coastal wetland, it is required that the site is predominantly populated by the same species that I have examined, within the same range of stem densities and within a similar range of Reynolds numbers. Thus, each problem needs to be considered on an individual basis, and it may be necessary for further investigations depending on specific site conditions. This highlights the importance for an engineer to be aware of the limitations of the data or models that are applied to provide solutions to environmental problems. It is for these reasons that there is no simple answer to the question which I was faced with: "if I was developing a model for a coastal wetland, what drag coefficient can you give me in order to run the model?"

Rami Malki
Cardiff School of Engineering

Water resource management planning in SE England

BHS South East Section meeting
ICE, London, 16th October 2008

Water Companies have been through the process of production and consultation on their draft Water Resource Management Plans. These plans address the provision of water supplies into the future, taking account of projections for growth and development over the next 25 years. The plans set out how to ensure secure water supplies whilst meeting the significant projections for new growth together with measures to address the environmental obligations arising from measures such as the Habitats Directive.

David Spiller from Thames Water described the planning process and how Thames had approached the development of its draft plan, highlighting the key issues involved in its preparation whilst addressing the need for delivering value for money and also taking account of the needs of stakeholders and the environment. He then covered the key features of the draft plan, including demand-side measures and resource developments required to meet for the proposed development in London and the Thames Valley. The draft plan sets out the need to retain focus on leakage reduction with continued Victorian mains replacement and the plan for widespread metering following the designation of much of the south of England as an area of 'Water Stress'. The draft plan also outlines the role of water efficiency for both existing housing stock and new developments. David emphasised that demand management alone will not be sufficient to meet water needs in the future and so the resource options required as part of the twin-track approach were set out. The key for the future was a major resource development later in the planning period to address the needs of both London and the Thames Valley. He also described the potential for future sharing of resources with

other companies in the south east. Following the consultation process, Thames Water will produce a Statement of Response and then go on to produce its final Water Resource Management Plan, taking into account the comments received on its draft plan.

A question was raised covering the operating cost comparison between the development of desalination and effluent re-use schemes. Whilst specific details were not available, the response was that re-use is an option with very high operating costs so, depending on the nature of the scheme, the treatment processes may be similar to those for desalination.

Another query concerned the assumed potential savings from metering and whether these savings were optimistic. The assumed savings are based on evidence from previous metering programmes and taking into account the customer base for Thames Water.

Nigel Hepworth from the Environment Agency gave the second presentation with a brief overview of the Water Resource Management Plans proposed by water companies in SE England and the main features of the plans. The key feature raised by Nigel was the implications of work done by the companies on the potential to integrate resources across the region through the Water Resources in the South East group convened by the Environment Agency. Nigel then went on to cover WRMP design concepts — thinking ahead to how the consistency and understanding of WRP outcomes can be improved.

Nigel's presentation highlighted that the modelling that had been done for the WRSE group indicated that a lower cost regional solution could potentially be achieved if some new resource development was offset through the development of inter company resource transfers. Where these potential options were highlighted, the respective companies were expected to explore these options in more detail.

Nigel then went on to address the issue of the basis for assessment of deployable output by companies, noting that the different lengths of hydrological record used by the different companies made comparison of deployable outputs difficult. It was recognised that the process of standardisation was not easy and that some generation of synthetic hydrological records might be required. It was also apparent that if longer records were used as the bases of deployable output calculations, the impact would be likely to be a reduction in deployable output, which would trigger the need for significant further resource development.

Steve Tuck
Thames Water

Extreme rainfall and flood forecasting

BHS South East Section meeting
ICE, London, 20th November 2008

More than 70 people attended this interesting evening meeting and were rewarded with two stimulating presentations and subsequent extensive discussions.

Max Little of Oxford University described work on probabilistic rainfall forecasting with statistical models. He outlined the importance of forecasts, the historic development of numerical methods for producing them, and the improvements that have been achieved. Forecasting inaccuracies were described as being caused by combinations of model error, measurement error and chaos. The relatively new concept of probabilistic forecasting using statistical models was introduced as a possible alternative. Methods of quantifying the accuracy of forecasts were described and used to compare a variety of statistical models against the outputs from super-computer generated numerical models for defined rainfall events in areas of the Thames valley. Results showed that sophisticated statistical models can produce forecasts for the near future that out-perform even super-computer models. Application of the statistical modelling methods is

possible, subject to consideration of particular forecasting requirements.

Mike Vaughan and **John Hall** from the Environment Agency, Southern Region, described hydrological aspects of the Southern Region Flood Forecasting System (SuRFFS). The system has been developed to support operational flood forecasting across the region. Hydraulic and hydrological models use close to real-time monitored telemetry data and forecast rainfall data to produce time-series flow and level forecasts at key points across the river network. Deterministic models based around PDM and ISIS are currently used within the system. Data quality and selection criteria for use of data from multiple sources was described. Implementing the system has involved development of methods for assessing how well the forecasts produced by models perform against observations. Problems were encountered with model calibration using water balances, in some cases giving rise to reassessment of data input quality. The system is designed to forecast if and when alarm thresholds will be crossed by rising (and falling) river levels. Optimising statistical measures of goodness-of-fit for the models was shown to fall short of meeting the needs for their use in forecasting. Model quality criteria also need to include prediction of when (and if) alarm thresholds are crossed. SuRFFS now forms the basis for the Region's fluvial forecasts but improvements to data collection and model performance are ongoing.

Joe Pearce, Environment Agency
Thomas Kjeldsen, Centre for Ecology and Hydrology

Sediment dynamics in changing environments

IAHS ICCE International Symposium
Christchurch, New Zealand
1-5 December 2008

The conference was based around the four main themes of sediment dating and source tracing, processes and scales in sedimentary systems, global change and erosion, and linking erosion with environmental and societal impacts. The research presented covered a diverse range of environments on five continents, showing a wide variety of sediment transfer processes but also highlighting the common factors of climate and land-use change affecting sediment behaviour in many catchments.

The range of spatial scales covered was very wide. In his keynote speech, **James Syvitski** presented estimates of sediment yield on a global scale, derived from his model BQART, which uses broad level environmental factors such as climate and topography to predict sediment yields from large river basins. However, other presentations, including my own, focused on predicting and understanding sediment dynamics at the catchment scale or smaller and demonstrated that we still have a lot to learn about processes at this scale. The keynote speech of **Andreas Lang** was an interesting review of developments in source tracing and dating technologies. The talks that followed on this subject showed that these techniques have allowed considerable progress to be made in understanding catchment sediment dynamics, and also have much potential for the future.

The significant role of sediment dynamics in society was illustrated by the many talks on sediment management issues. In his thought-provoking keynote speech **Michael Crozier** showed that the effects of rapid global population growth in the last 50 years include problems and pressures related to sedimentary systems. The management and mitigation of these problems is an important task for geomorphologists



The Rakaia River, Canterbury, New Zealand, visited during the conference field trip.

and hydrologists now and in the future. The important interaction between human activity and fluvial sediment loads was again highlighted in **Des Walling's** keynote speech on the changing sediment loads of the world's rivers, where he suggested that human activity has had a significant influence on recent changes in the sediment loads of many rivers globally.

One of the highlights of the conference was the field trip which began with an interesting talk about the water issues of the Canterbury region by **Bryan Jenkins**, Chief Executive of Environment Canterbury. We then visited some of the very dynamic rivers of the Canterbury plains and uplands. These included the impressive Waimakariri River, one of the largest braided rivers in New Zealand, which requires management of gravel extraction to reduce the flood risk associated with sedimentation.

I felt that the conference highlighted the complexity of sedimentary systems and how much there is still to learn about sediment production and transfer processes in many catchments and at the larger scale. However it also showed the developments in many field and modelling techniques which are helping this progress. I found it an excellent opportunity to meet other scientists working on similar issues to myself and to present some of the work I have done for my own PhD on sediment dynamics in the River Eden catchment. My thanks to BHS for the Travel Grant which made the trip possible.

Carolyn Mills
University of Newcastle

Water for People and Life: water quality and quantity conflicts in the Solent

BHS SE Section meeting
22 January 2009

The Solent area of the south coast is characterised by the urban conurbations of Southampton and Portsmouth, which are in turn surrounded by high priority marine and fluvial Habitats Directive designated sites. Site investigations have resulted in the need for changes to abstractions and discharges both along the coast and in the catchment of the River Itchen.

The two presentations considered the impacts of people, potential growth, abstraction and wastewater discharges in the natural environment. The first presentation was given by **Dave Lowthion**, Marine Team Leader at the Environment Agency and the talk focused on the marine and estuarine

discharge impacts within the Solent.

As part of the Habitats Directive Review of Consents (RoC) process, intensive water quality sampling was undertaken to record the baseline situation in the Solent. The chemistry and biology were sampled at the end of discharge pipes in the intertidal zone. A range of metals and organic substances were measured as well as the benthic invertebrate populations. At some locations the extent and scale of thermal plumes were assessed. The final assessment considered these observed impacts as well as potential impacts if any headroom in permissions was fully utilised. Green seaweed was observed to be a problem in the harbour areas around the Solent due to increased nutrient loading. Excessive amounts of weed have a knock-on impact on invertebrate populations and consequently the internationally important bird populations.

Nutrient and hydrodynamic modelling was undertaken to look at the distribution of nutrients such as nitrogen across the Solent, and this led on to the development of a weed growth model to determine the relative contributions of seaweed resulting from river and marine permissions (point source) and river and marine diffuse sources. A green weed benchmark target was developed (no previous standard existed) which equated to the average biomass of medium weed cover (25–75% cover). This was used to develop an action plan to reduce the impact of consented discharges on green weed growth. As a result, nitrogen standards were set at 10 mg/L on most major waste water treatment discharges. In order to reduce diffuse source pollution, all contributing surface water catchments to the Solent have been designated as Nitrogen Vulnerable Zones and catchment sensitive farming initiatives have commenced.

Future growth in the Solent area, and therefore effluent, could undermine the benefits of nitrogen control as part of the Habitats Directive RoC process. A local standstill has been adopted as policy and more nitrogen needs to be removed to balance the increase in effluent quantities.

The second presentation was given by **Julie Morris**, Principal Officer (Water Resources) at the Environment Agency, and detailed the impact of abstraction on the River Itchen SAC and the implications for water resources planning. The River Itchen catchment supports a considerable amount of surface water and groundwater PWS abstraction and, prior to the RoC work, no previous 'Hands-Off Flow' conditions existed on the river, which is unusual. The Habitats Directive Stage 4 report for the River Itchen (published in October 2007) detailed that changes would be required to four of the PWS abstractions and these decisions were based on achieving the required environmental outcomes, which were linked to the integrity of the SAC. For the River Itchen, these environmental outcomes focused on salmon and invertebrates.

Invertebrates are a good indicator species for the health of the river and correlations with invertebrate community data and flow data were undertaken. The analyses indicated that significant impacts to the invertebrate community were seen below threshold levels. This led to the development of a series of rules to protect the invertebrate community. To meet the required invertebrate flow regime, reductions in monthly abstraction is required for these four PWS sources for August and September and the imposition of HOF conditions are also required.

Atlantic Salmon are also an important consideration in the health of the river and are currently in unfavourable conservation status. A salmon entry (migration) model was used to consider the impacts of abstraction on salmon in the River Itchen. This identified that further reductions in monthly abstraction were required for all these licences in June and July.

The impact of the licence changes has an impact on the supply–demand balance for the water companies and there is a need to put both supply and demand options in place to counter balance this (Southern Water's available supplies in its Hampshire resource zone will be halved). This process is considered in the Water Resource Plans for each water company and Final Plans will be submitted to Defra and the Business Plans to Ofwat in the near future.

Helen Proctor
W S Atkins & SE Section Committee

Hydrology Research

the official journal of BHS, joint with the Nordic Association of Hydrology, is getting in its stride, with a couple of papers in the recent issue authored by BHS members. If members go on-line to the journal site, they can access the contents of the current issue, Vol. 40, No. 1.

Contents of HR*j*, vol 39, Nos 5-6

Assessing the value of Cl^- and $d^{18}O$ data in modelling the hydrological behaviour of a small upland catchment in northeast Scotland
Sarah M. Dunn and Jeffrey R. Bacon..... **337–358**

Impacts of peatland drainage on the properties of typical water flow paths determined from a digital elevation model
Timo Korkalainen, Ari Laurén, Harri Koivusalo and Teemu Kokkonen..... **359–368**

Fitting depth–discharge relationships in rivers with floodplains
Asgeir Petersen-Øverleir..... **369–384**

Flood regimes in the Southern Caucasus: the influence of precipitation on mean annual floods and frequency curves
J.V. Sutcliffe, F.A.K. Farquharson, E.L. Tate and S.S. Folwell..... **385–401**

Estimating mean monthly runoff at ungauged locations: an application to France
Eric Sauquet, Lars Gottschalk and Irina Krasovskaia.....**403–423**

Trend analysis in Icelandic discharge, temperature and precipitation series by parametric methods
Jóna Finndís Jónsdóttir, Cintia B. Uvo and Robin T. Clarke.....**425–436**

Isotope variations of throughfall, stemflow and soil water in a tropical rain forest and a rubber plantation in Xishuangbanna, SW China
Wen Jie Liu, Wen Yao Liu, Jin Tao Li, Zhe Wen Wu and Hong Mei Li..... **437–449**

Hydroclimatic analysis of an ice-scar tree-ring chronology of a high-boreal lake in Northern Québec, Canada
Mickaël Lemay and Yves Bégin.....**451–464**

The effect of climate change on design floods of high hazard dams in Finland
Noora Veijalainen and Bertel Vehviläinen..... **465–477**

Seasonal groundwater storage anomaly and vadose zone soil moisture as indicators of precipitation recharge in the piedmont region of Taihang Mountain, North China Plain
Shumin Han, Yonghui Yang, Yuping Lei, Changyuan Tang and Juana P. Moiwo.....**479–495**

Prediction of salinity intrusion in Danshuei estuarine system
A. Etemad-Shahidi, A. Dorostkar and Wen-Cheng Liu.....**497–505**

A National Flood Emergency Framework

Defra have launched a consultation exercise on the proposed policy framework for flood emergency planning and response. The aim is to produce a document that goes beyond listing existing provisions and provides a reference point for planning and response for all tiers of local, regional and national organisations. Instead of simply asking for written comments, a series of one-day workshops in each of the nine Government Office regions are to take place before the end of March 2009, to which representatives of organisations with primary and secondary roles in planning and response will be invited.

The following six proposals are being developed to narrow down what those charged with on-the-ground emergency planning and

response may need, i.e. the missing elements from existing 'toolkits'.

- the Met Office and the EA should develop new, formal arrangements to provide specific flood risk advice in the lead-up to potential flooding.
- Lay down what you can expect of the Government and its agencies in the event of a flood emergency
- Ditto for health care
- Definitive guidance on multi-agency planning for flooding all types and at all necessary geographical levels
- Arrangements for mutual aid in the event of predicted and/or actual flooding
- An electronic compendium of information, advice and guidance

Views on whether these assumptions are correct are welcome, and also how these could be improved to minimise any burden on businesses and the public section.

The full report can be seen at www.defra.gov-uk/corporate/consult/flood-emergency/index.htm and responses are requested by **27 March 2009**.

If you feel that a BHS response is appropriate, please contact our Technical Secretary.

Support for BHS Regional Sections

One of the strengths of BHS is its active regional presence. At the last Main Committee meeting, we discussed at some length the support for regional activities, particularly meetings and field trips, and thought it would be helpful for members to be aware of the key points raised.

Most importantly, we have agreed that there should be a standard route for financial support so that secure arrangements can be made for all meetings. Some of the longer standing regional groups have had their own bank accounts in the name of BHS but there have been problems with regional bank accounts when there have been changes in local committees. Indeed, it is no longer acceptable for regional sections to have local bank accounts because of issues of audit and accountability, in particular because the Society's accounts have to be examined independently before submission to the Charity Commission.

Please note that there is no specific allocation for regional activities; the level of support offered will depend on the activities planned and the cases made.

In future:

- Regional committees should submit an annual budget to the Hon Treasurer prior to the October meeting of the Main Committee, indicating plans for the forthcoming year.
- The Hon Treasurer will respond, indicating the degree of support available from central funds (after appropriate discussions if required).
- The regions should submit invoices and/or receipts to the Hon Treasurer for approval and payment from the Society's account held at ICE.
- The Hon Treasurer will aim to be flexible regarding variations from the submitted budgets, but significant changes should be advised to the Hon Treasurer in advance.
- These procedures should not replace any existing arrangements in the regions. In particular, sponsorship of meetings is most welcome. Direct sponsorship income should be paid into the central BHS account via the Hon Treasurer/ICE. Alternatively, it may be agreed that a sponsor will directly meet some specific costs associated with a meeting.

Support in 2008/09

For the remainder of the current financial year regional committees should submit requests for support to the Hon Treasurer as soon as possible.

Peter Ede

Work Experience

A previous issue of *Circulation* noted that the then Young Members Rep on the main Committee (Tim Norton) had set up a contacts list of those who were willing to consider requests for work experience. These contacts are throughout (and occasionally beyond) the UK, with a possibility for a wide range of hydrological work. Members should know that this list is still active (and we would welcome more offers of help) and is being flagged up on our 'Hydrological Gateway' page on the web. Anyone wishing to wish to explore this matter further, please send a message to me, outlining your capabilities and the kind of experience you seek. Relevant BHS members who may be able to help will then be contacted on your behalf. All opportunities are dependent upon the goodwill of members and their employers and therefore the list is not publicly available.

Celia Kirby
(celia.kirby@btinternet.com)

Young Science and Engineering Fair
QE2 Exhibition Centre, London
4th-6th March 2009

The Science Council tells us that they are helping to shape this fair, with the desire to bring in the concept that science and careers are exciting, stimulating, multi-disciplinary and offer huge potential. They hope to produce three inter-disciplinary exhibition displays for the Fair, including an ecosystems display. This is to focus on the importance of water as a resource for food, health, industry, development and sustainability. It is also hoped that this stand would be a chance to look into (I quote) "....the effect of bad management such as planning and flood defences".

Should be intersting!

Stop press...

An **International Conference on Water Policy** is to be held in Prague, 22-26 June 2009.
Furher details: www.fzp.czu.cz/wat

Travel grants

Travel grants are awarded from the Society's general funds to help BHS members whose travel expenses to attend scientific meetings are not met by an employer. Applicants should have been members of the Society for at least six months. The amount will depend on the nature and location of the meeting and the case put forward. Priority is given to members under 35 or retired from employment, who are presenting papers and who have not previously received support from BHS. Successful applicants will be expected to write a short report for *Circulation*. Travel grant applications should be made to the Hon Treasurer at least two months before the conference or meeting.

To apply, use the form at *www.hydrology.org.uk/about_awards.htm* or contact **Peter Ede**, Mott MacDonald Group, Demeter House, Station Road, Cambridge, CB1 2RS *(tel 01223 463690, email peter.ede@mottmac.com)*.

Editorial

Just a brief note to flag up our web pages for those who don't look at them regularly. We are putting more effort into keeping these up to date, including refining the links to BHS Publications, the majority of which are now available in pdf format. The diary of forthcoming hydrological events, at home and abroad, is naturally more informative than we can provide in this newsletter and there are links for job adverts, data sources and much more.

Celia Kirby

Forthcoming Events

Liaison with CIWEM

A series of meetings is to be organised alternately by CIWEM and BHS. The purpose is to provide a link between water resources practitioners and hydrological researchers, and to ensure that hydrological research addresses water resources planning needs and that water resources planning practice adopt developments in hydrology in a timely and appropriate manner.

Meetings will be organised once every two years (i.e. in a **non**-BHS Symposium year) under the umbrella theme of 'research into practice' with the overall objective to direct research efforts towards practical needs and to encourage the early uptake of research. The first meeting is to be run by CIWEM this summer - see diary entry.

International symposium
From the Hurst Phenomenon to Earth Systems Engineering
Newcastle University
26-27th March 2009

Professor Enda O'Connell retires from full time work at Newcastle University in April 2009, following a career spanning 40 years. This international symposium, being held to celebrate his research achievements, is an opportunity to participate in a cutting edge review of hydrological science and applications and to join many of the friends and colleagues who have worked with Enda over the years.

The symposium is open to all but as attendance will be limited by the size of the conference facilities, early booking is encouraged. Further details from: claire.walsh@ncl.ac.uk.

The symposium also coincides with the launch of the recently announced EPSRC-funded Platform Grant in 'Earth Systems Engineering' at Newcastle University, and is supported in part by EPSRC.

Looking ahead....

BHS Third International Symposium, Newcastle University 2010

As you are all aware BHS organises a full programme of national and regional scientific meetings each year covering a range of topics and issues. BHS also organises a three-day national symposium every two years. In addition, every six years there is a BHS International Symposium. The International Symposium aims to bring together hydrologists from the UK and overseas during a week long conference to discuss relevant issues and challenges facing hydrology and related disciplines. In 2010, the third International Symposium will take place at Newcastle University from 18–23 July. In addition to a full programme of keynote speakers, oral presentations, field trips and poster sessions there will be an accompanying social programme including a cruise along the River Tyne, a conference dinner and a debate and quiz evening.

Planning is now fully under way for this event and further details on the themes of the symposium and details on how contribute a paper or a poster will be circulated shortly. There will also be opportunity for exhibitors to attend the event.

Please put the date: 18–23rd July 2010 in your diaries and we look forward to welcoming you to Newcastle University and Newcastle upon Tyne.



Royal Meteorological Society
Meteorological Science in time and space - from local weather to global climate
University of Reading
29 June – 2 July 2009

There are three conference themes:
- The Water Cycle: from local rainfall to global changes in the hydrological cycle.
- Predicting Hazards and Risk: from local weather forecasts to dangerous climate change.
- Ecosystems, Atmospheric Composition, Weather and Climate: from urban air quality to earth system processes.

UNESCO Workshop on Modelling for Adaptive Water Resources Management
to be held at **the 18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation, Cairns, Australia**
3–17th July 2009
http://www.mssanz.org.au/modsim09/
Organiser(s): s.khan@unesco.org, serena.chen@anu.edu.au

The workshop objectives are to:
* Examine the ways and extent to which modelling frameworks, models and engagement processes can indicate high leverage sources of data, information and knowledge to progress management options and investments
* Define research problems (challenges/ issues) and scope tools that require further development
* Examine ways to increase the transparency of the management/decision-making process
* *Provide a reality check for a state of the art and future directions position paper being developed by the authors and interested workshop attendees*

Please submit abstracts online. Limited support is available to IHP HELP network members with accepted abstracts.

7th International Conference on River Basin Management, Malta
7–9 September 2009
Call for papers
to include all aspects of Hydrology, Ecology, Environmental Management, Flood Plains and Wetlands
Full conference information is available at:
http://www.wessex.ac.uk/rbm2009rem1a.html

Copy deadline for* Circulation *No. 101
17th April 2009

Diary

12th February 2009
4th annual Catchment Science Centre Conference
"Complexity and Uncertainty in Catchment Management"
Venue: University of Sheffield
Contact: j.a.chambers @shef.ac.uk or www.shef.ac.uk/csc

12th March 2009
"Making space for water - future of urban hydrology"
BHS National Meeting
Venue: Newcastle University (include field visit to the Ouse Gill catchment).
Contacts: Claire Walsh (claire.walsh@ncl.ac.uk and Mark Wilkinson (mark.wilkinson@ncl.ac.uk)
Postponed

19-24 April 2009
European Geosciences Union General Assembly
Venue: Vienna
http://meetings.copernicus.org/egu2009/

6th May 2009
"Emerging challenges in flood hydrology"
BHS National Meeting
Venue: ICE
Contact: Claire Samuel (csamuel@pba.co.uk)

3rd June 2009
"Developing best practice in water resources planning"
Venue: SOAS, London.
Convenors: Colin Fenn and Frank Farquarson

18–19th June 2009
Peter Wolf Young Hydrologists symposium
University of Liverplool
Contact: Neil Macdonald (neil.macdonald@liverpool.ac.uk)