Circulation

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The Newsletter of the British Hydrological Society

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President's Piece

Last time I touched on the subject of diversity. The Main Committee discussed this at some length at our meeting in April, following a meeting on one aspect of diversity (gender) that was organised by a group of students in Bristol and advertised through BHS (see report elsewhere in this issue). That meeting included the presentation of some BHS membership statistics showing an approximate gender balance amongst young members (in fact there are more women than men amongst our under-30s), while in older cohorts like my own there is a large majority of men. This might suggest that the "issue" will resolve itself in time, but committee members were clear that we should investigate ways in which we might proactively seek to encourage greater diversity in Society activities. We don't intend this to be limited to gender, but that is an aspect of diversity that is easy to assess, and whilst demonstrating gender diversity does not necessarily imply diversity in respect of other characteristics, I am sure that if we cannot demonstrate gender diversity we are almost certainly failing in other areas as well. We are setting up a sub-group of the committee to look at this and will report back in due course.

Over the years the various regional groups of BHS have tended to wax and wane in line with the enthusiasm of particular individuals or groups of members. Little has happened in recent times in the Midlands or the South West, but the Pennines group is enjoying a resurgence and the Scottish Hydrological Group is showing promising signs of rebirth. Through all of this the South East group has been a constant, with a series of evening meetings from autumn to spring every year, plus some summer events. I had hoped to attend the final 2018-19 meeting and be able to take the opportunity to thank Vicky Crellin who has been organising the South East meetings for the past six years, but the cancellation of all trains from Cambridge stymied my plans. The Society depends on people like Vicky being willing to give up a little time to help with meeting planning and organisation, but the benefits gained in terms of knowledge acquired and people met can be very worthwhile. You don't have to commit to the length of time that Vicky has served; please get involved in whatever way you can.

It's election time again (and no need to form new Brexit-related parties), with nominations invited for Ordinary Committee members for three-year posts starting in September. Do please consider whether you could potentially contribute to the Society in this way, or perhaps you would like to nominate a colleague (with their agreement!). The Society needs keen committee members to help it to move forward, and it is also a good opportunity to further your own professional development.

Peter Ede
President

Flood Forecasting 1 and 2: inputs and future challenges

The BHS Pennines Group began their spring programme with a Flood Forecasting double-header, both hosted in the excellent facilities afforded by Water@Leeds.

The first meeting, on 31st January, "Rainfall; the input" drew a full house of 60 from among the hydrological community of consultants, regulators academics and students.

Louise Parry (ARUP) kicked off with a presentation entitled 'Flood forecasting – the challenge of linking rainfall and hydrological models'. Drawing from her PhD and her experience as a forecaster with SEPA, Louise gave an excellent overview of the forecasting problem, illustrating it with reference to two well-known events north of the border; 'Storm Frank' and the 'Day of the Don'. Key themes were the use of multiple sources of rainfall data to make up a single forecast, and the 'Cascade of uncertainty' that resulted from measurement or prediction errors as they propagated down the chain of linked models to make a forecast for a downstream reach. Louise noted that rain gauges are still preferred to radar data even though tipping bucket gauges are associated with errors of up to 20% and that even in smaller catchments, current forecast models can show a 45% variation in predicted rainfall. Louise concluded by saying that we need to think of new observation methods to try to reduce uncertainty and a better way of communicating the risk and the uncertainty of forecasts to the public.

Alan Gadian, of the National Centre for Atmospheric Science took up the baton, focusing on 'Modelling, radar and remote sensing of precipitation'. Alan noted that radar can miss up to 50% of rain droplets and that the Met Office's current C-band, operational network does not cover the whole of the UK. Alan's thought provoking talk examined the difficulties in forecasting small scale convection events, noting how damaging they could be in small catchments, and how the scale of storm cell formation was problematic even for high resolution atmospheric models (such as the Weather Research and Forecasting Model) that represented the physics of convection, never mind for the larger scale climate models more routinely used in climate modelling. Alan cited two examples from the Pennines patch, Boltby Reservoir in the North Yorkshire Moors which was damaged by flooding in

June 2005 and Ulley Dam near Sheffield which nearly collapsed after torrential rainfall in June 2007. Alan's view was that even though high resolution models offered improvements in estimating rainfall volume, they still miss the location of these high intensity convective events.

Cathryn Birch and **Steve Boeing** from the Yorkshire Integrated Catchment Solutions Programme (iCASP) at the University of Leeds presented the third talk on 'Enhanced surface water flood forecasts and warnings'. Their project aims to test the feasibility and usefulness of converting the latest advances in probabilistic rainfall forecasting and high-resolution surface water modelling into real-time forecasts and/or warnings for Lead Local Flood Authorities (LLFAS) and other decision-makers. Their project team involves staff from the National Centre for Atmospheric Science, JBA Consulting, the Environment Agency, the Met Office, City of York Council, Leeds City Council and Yorkshire Water. They discussed how surface water flood forecasts have been limited to relatively coarse-scale county-level red/amber/green warnings issued by the Flood Forecasting Centre with static risk maps.

The project will test the feasibility of using probabilistic forecasts locally through a review of current methods, the development of improved probabilistic forecasts and by testing the implementation of these new forecasts in an incident workshop. Issues surrounding probabilistic forecasting included the time taken to run the ensemble models and also how well recipients understand and respond to them, making the social science aspects as important as the hydrology.

The second meeting was held at University of Leeds on 27 February 2019, and was entitled: "Flood forecasting challenges and future directions".

Whilst the first evening focused on the inputs used to run flood forecasting models, the second considered how the EA use information to generate a forecast, and how the outputs are used to inform and prepare the public. To help explore this, three members of the team developing the EA's Future Flood Forecasting System, FFFS, gave talks about the new system. Once it becomes live, it will enable a step change in the technical capabilities of the EA to provide reliable forecasts, and to provide forecasts which are easier for operators and the public to understand.

Neil Ryan (Environment Agency) began the meeting with a strategic outline of the Environment Agency's vision for flood forecasting over the next 5–10 years. Neil talked about the move to the EA's next generation forecasting system (FFFS), and gave an indication of how functionality such as real-time inundation mapping and ensemble forecasting will be used to enhance the dissemination of forecast outputs to people.

Following this, **Adam Clarke** (Mott MacDonald) talked about the EA's real-time modelling strategy, including the conversion of over 750 rainfall-runoff and routing models from a range of software types to use consistent packages, and thus realise significant efficiencies in operational forecasting; as well as laying the groundwork for the future service enhancements outlined by Neil. Adam then talked through changes to the EA's model development processes for real-time modelling, including new calibration standards, methodologies

for performance testing, and a move towards asset management principles for managing forecasting model assets.

Paul Wass (JBA) wrapped up the evening by outlining the enduring benefits of flow routing methods in flood forecasting, drawing upon the principle of "*Simple is Efficient*"! Paul outlined how a simple conceptual modelling approach, coupled with innovation and an understanding of different routing formulations, allowed the EA to deliver the 750 models within very challenging timescales; in time for configuration into FFFS.

Overall, the two evenings were a great success with a lot of lively debate and a chance to get in-depth input from our meteorology colleagues. The double-header format allowed a key application of hydrological science to be explored in more depth than a single event, helping to build understanding about how hydrological science can directly benefit society by reducing risk to people and property.

Thank you to water@leeds for hosting both meetings and to the speakers for sharing their time and experience. The BHS Pennines hydrology group are currently working to build an autumn programme of talks. We are keen to encourage a more diverse range of speakers and attendees and a broader spread of locations and topics across the region, so would welcome any discussions or volunteers for future talks.

Victoria Coates and Chris Allman
BHS Pennines Committee Members

CBHE is 21!

The Society's Chronology of British Hydrological Events (at cbhe.hydrology.org.uk) is 21 years old - how time flies! Established to provide a central repository of details of hydrologically significant events, it has been well recognised and used by hydrologists particularly working on flood risk studies (endorsed in the Flood Estimation Handbook). However, it's now more than a year since the last new entry has been added. Perhaps a review and refresh is warranted.

Now may therefore be a good time to canvass ideas from users of the Chronology - is it meeting your needs? How would you like it to be improved? Two of the plus points of the Chronology to date have been its resource efficiency - it cost £20 to set up (!), and its relative simplicity; it has never had major resources allocated to it. But perhaps we need to be more ambitious in thinking to the future.

If you'd like to share any experiences or views, I'd be glad to hear from you.

Andrew Black
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Joint CIWEM-BHS National Meeting

Celebrating hydrometry
Monday 24 June 2019

Institution of Civil Engineers, One Great George Street, London

This joint CIWEM-BHS national meeting (part of an ongoing series of meetings designed to link researchers, policy makers and practitioners) will provide an excellent opportunity to learn more about the value that hydrometry provides for society, the environment and the economy. It will feature presentations and debate from those responsible for the collection and management of hydrometric data, through those who utilise it for studies, modelling and critical decision making, to the less obvious users who gain value from it.

Who should attend?

The meeting will bring together academics, researchers, consultants, hydrologists, environmental managers, policy-makers, regulators and other stakeholders.

What will you learn?

The meeting will be of interest to all who rely on good quality, long-term hydrometric data records to make informed, robust decisions on water resources management and flood risk, whether that is planning a new reservoir or flood alleviation scheme, through to abstractions and discharges. Good quality, continuous hydrometric data underpins almost every aspect of the way society interfaces with the hydrological cycle, yet can be undervalued, overlooked or misunderstood by many decision makers. This meeting seeks to promote the value of the ordinary – the seemingly routine observations of our rivers and streams, the groundwater beneath our feet, and the rainfall and other parameters that are measured – and recognise its importance and wider benefits for consultants and practitioners, as well as wider society, the environment and the economy, across the whole spectrum of water management. It will also signpost emerging developments in this field, and explain how concepts such as open data, big data and citizen science sit alongside technical standards, quality assurance and expert judgement to take hydrometry forward.

Confirmed speakers include:
Nigel Goody, SEPA; Maxine Zaidman, JBA; Dr Paul Johnson, Trinity College Dublin and Paul Hickey, EA plus Jón Ottó.

Meeting organiser:
Adam Comerford
Canal & River Trust and CIWEM Water Resource Panel
Adam.Comerford@canalrivertrust.org.uk

UK reservoir spillway flood hydrology

Joint BHS-BDS National Meeting Institution of Civil Engineers, One Great George Street, London

This meeting, organised by Ian Littlewood (Independent) and Duncan Faulkner (JBA Consulting), filled the Thomas Telford Lecture Theatre at OGGS (capacity ~110) with about equal numbers of BHS and BDS members. The first two sessions were chaired by Peter Ede (BHS President) and Allan Warren (BDS Chair-Elect). The final discussion session was chaired by Anita Asadullah (Environment Agency, Floods Team) This joint meeting of the BHS and British Dam Society brought together members of both societies to discuss and debate the question: "Should current standard techniques for UK reservoir and spillway design flood estimation now be comprehensively reassessed with a view towards their possible improvement, or even replacement?"

Duncan Faulkner, from JBA, gave an excellent introduction, which included a summary of the numerous uncertainties in the estimation of PMF and the reason for the conference, including assumptions in PMP, FSR rainfall-runoff; time to peak; snowmelt, frozen ground; climate change; use of HOST data; estimations of fixed percentage runoff and the potential for using paleo data.

David MacDonald (independent) set the scene for the day, with reflections on the FSR and FEH methods of design flood estimation gained throughout his career. In particular David challenged the use of a bell-shaped storm profile for long duration events, and highlighted that this assumption should be considered carefully for longer storm durations, where it is highly unlikely to occur.

Joao Correia, from Atkins, gave a considered summary of contemporary approaches to Reservoir Flood Studies, including two case studies that highlighted the sensitivity of ReFH2 to high urbanisation, and the contrast between time-to-peaks developed using FEH, FSR and ReFH2.

Colin Clark from Charldon Hill Research Station gave a talk which challenged the current methods for flood estimation and in particular stressed the importance of stepping away from the computer and into the field and collecting data for parameters such as percentage runoff to understand whether what we are using in our hydrological models is suitable. Colin also presented arguments for supplementing traditional rain gauges with less formally collected data sources, such as buckets.

Alan Warren from Mott MacDonald gave an Inspecting Engineer's perspective of reservoir flood studies. He emphasised that the consideration of flood risk goes beyond the hydrological processes outlined in the guidance, and highlighted the importance of blockage (from ice, debris, or soil wash-off), and of resilience to overtopping. Alan identified

the need for operators to be mindful of changes in catchment area, reservoir operation, freeboard and downstream vulnerability. In particular Alan highlighted how historic changes in guidance have impacted on reservoir owners' expenditure and made a plea for less frequent changes in the methods and guidance.

David Mould from Canals and Rivers Trust provided the perspective of the reservoir operator, and presented some practical experience gained from recent reservoir flood studies. He stressed the importance of getting out in the field before a flood study to look for unusual hydrological features which will affect your assessment, including unusual flow pathways that may affect catchment areas.

Thomas Kjeldsen (University of Bath) presented the outputs of a case study in a Korean catchment, where rainfalls that would be considered 'extreme' in the UK are relatively common. The study compared time to peak against rainfall depth, finding that the measured time to peak for more extreme rainfall events could be much smaller than those derived from ReFH. This is represented when estimating PMF using a practical adjustment of 0.67 to time to peak is applied. The paper highlighted that the trend for shorter time to peaks can also be seen in much smaller magnitudes of event.

Lisa Stewart from CEH summarised the ongoing development work which has been used to suggest priority areas for research, including an interesting analytical inter-comparison of design hydrograph outputs from combinations of methods (including FSR, and the FEH99 and FEH13 DDF models) which are typically used in reservoir design flood estimation to understand the differences between each.

Mark Macklin from University of Lincoln (and other institutions) gave a stimulating introduction to lichenography for the uninitiated, and presented ways that the paleoflood records could be incorporated into UK flood frequency estimation. In upland catchments, lichen sizes can be used to date boulders that have been moved in a flood; the size of the boulder can be used to identify event magnitude. In particular that the paleo record indicates that the bulk of the UK instrumental record dates from a relatively flood-poor period compared to the long term history.

Ian Littlewood (Independent) ended the day with a challenge to ask why we are stuck with using old methods. To demonstrate, Ian considered alternatives to the triangular unit hydrograph method developed as part of the FSR, in particular the IHACRES model, and compared the outputs which could be achieved by using a different approach. He laid a challenge before the audience, that it could be possible to get improved methods by challenging old assumptions.

The day prompted opportunities for discussions during breaks, and during two formal discussion periods. **Peter Ede**, BHS President, led the first discussion to draw out what the meeting thought were the most pressing research needs (there are a lot! – PMP, storm profiles, climate change, among others).

After summarising the EA's ongoing Flood Hydrology Road Map, **Anita Asadullah** led the second open discussion to close off the day with a lively debate about the priorities of investment in flood hydrology. It was evident from the amount of conversation from those leaving the lecture theatre and continuing out on to Great George Street that the day had raised awareness and a great many new questions. There is so much uncertainty surrounding the estimation of floods for reservoir safety and the photos of decimated communities shown by several speakers reinforced the potential implications of uncertainty in this area, which is undoubtedly one of the greater consequences in hydrology. Hosting a combined event with the British Dam Society brought a practical and real-world view from reservoir engineers, and highlighted why it is important that more work is carried out to reduce or quantify uncertainty.

Luke Ballantyre
Ove Arup & Ptnrs
Chris Allman
Mott Macdonald

The Speakers' slideshows can be seen at www.hydrology.org/publications.php/.
Please search 'Meetings Presentations' + date and/or author(s)

This BHS National Meeting was held at Lancaster University on 24th April, just before *Circulation* went to press, so a full report will be in the next issue. Meanwhile, the presentations from the meeting will be uploaded shortly on the web site under 'Publications' so watch for an announcement via Mailbase.

Quality through Equality : tackling gender issues in hydrology

Results of a 1-day workshop organised by Bristol University's Water Engineering Group

A professor asked our group of PhD students last year, "Who here thinks of staying in academia after finishing their PhD?" Of the 10 male students present, 4 or 5 said they could imagine doing so. None of the 5 female students raised their hand. When asked for their reasons for not wanting to stay in academia, some of the things mentioned were the challenge of combining family and academia, a lack of role models or different career aspirations.

This experience started the idea of organising a workshop on gender issues in hydrology, with the aim of raising awareness of unconscious biases, offer role models and discuss ideas on how to make the hydrologic community more diverse. Although the focus of the workshop was on gender diversity, most things we learned apply as well to issues related to misrepresentation of ethnic minorities or disabled scientists.

To achieve the aims mentioned above, the workshop included: three invited speakers (**Prof Hannah Cloke**, **Dr Joshua Larsen**, **Prof Elena Toth**) who shared their experiences regarding gender issues in hydrology; a talk and a training on unconscious biases (Prof Havi Carel); and a group discussion. The workshop was attended by 44 hydrologists, mainly PhD students, of which 28 were female and 16 were male.

One highlight of the day was the presentation of Hannah Cloke talking about her career progress to full professor while at the same time raising four kids. Together with Elena Toth and Joshua Larsen, she agreed that combining academia and raising a family is possible, because academia offers one of the most flexible work environments possible. However, it does need a supportive stance of the university to enable that flexibility (flexitime working hours, childcare facilities, flexible childcare support for conferences) and supportive colleagues. Hannah finished with good advice for all PhD students, but especially women or members of minorities:

A work-family-life balance is essential.
Say no before you are overwhelmed and exhausted, but: be brave!
Say yes to opportunities that scare you and do great science!
And encourage each other to be brave.

This is definitely good advice to try to implement in our lives.

The afternoon included an unconscious bias training by **Havi Carel** (you can watch her TED talk about unconscious bias here: https://www.youtube.com/watch?v=ruKrqgPMiis) and group discussions around how academia can become more diverse and how we can create an enjoyable academic environment.

Some of the topics we discussed were:

- What can senior and peer colleagues do?
  Often postgraduate and early career researchers suffer from lack of communication at their institutions. Peer-to-peer mentoring or senior-to-junior mentoring may offer opportunities for discussion to take place, particularly about equality/inclusion/diversity issues. When exclusion/discrimination problems are experienced/witnessed, having a range of peer and senior people to discuss with becomes very important, and facilitates reporting to leadership if needed. These meetings and discussions will also give opportunities to people who may otherwise feel their problems are overlooked, to find support, be empowered and build up their self-confidence.
- What can leadership do?
  To specifically include researchers with caring responsibilities, some attendees mentioned that it would be helpful if institutions could improve access to affordable childcare – this may include nurseries at University as well as more flexible reimbursement for childcare during specific events, such as conferences, where children cannot be brought along by parents.
- What is the role of role models?
  The attendees agreed that role models can be vital in shaping career pathways as they inspire, work as advisors and can start or change career aspirations. Role models should be relatable (by gender, ethnicity, etc.) and are thus not always available in less diverse environments. However, if role models do not exist new ways to develop them can be used and should be encouraged. For example, Twitter or other social media can offer a great selection of diverse role models from all over the world.
- What is success in academia (or in life)?
  Success can be defined in many ways. Some people want to make a difference, some want to publish high quality material, some want a good work-family-life balance, and some want all of those together. This highlights how important it is for line managers, supervisors, and colleagues to accept and nurture this diversity. A redefinition of success should be flexible and shaped according to the people in a certain work environment. This will hopefully lead to a more enjoyable and a more productive work environment.

The feedback we received from the day was overwhelmingly positive. This includes both talking to attendees and evaluating questionnaires that people filled out at the end of the day. The discussions about the topics and the opportunity to share experiences with others were found to be the highlights of the workshop. A large proportion of the participants felt more aware about biases and more empowered to tackle them. Some changes are already happening as a result of the workshop, for example our research group is diversifying social activities to be more inclusive. Meanwhile, both the British Hydrological Society as well as the Young Hydrologic Society have appointed EDI (Equality, Diversity & Inclusion) champions. With one-third of the 44 attendees being male, the workshop demonstrated that it is not only women who are interested to learn about biases and discuss their experiences.

We thank the GW4 Water Security Alliance, the Cabot Institute and the School of Engineering of Bristol University for funding this event. A big thank you to our three speakers and Havi Carel who conducted

the training, and to all attendees for creating an inclusive and productive atmosphere. Now it is our task to implement what we have learned and communicate the results as widespread as possible. And on a personal note, I definitely feel there is a future in academia for me now.

If you are interested in organising a similar event at your institution and have any questions, feel free to contact us: hydro-equality2019@bristol.ac.uk

Further information and material can be found on our website: **https://tinyurl.com/qualitythroughequality**

Some further reading about the topic of diversity and bias in STEM can be found here, including a list of scientific literature documenting the challenges women and minorities face in STEM subjects.
https://www.cfa.harvard.edu/~srugheimer/Women_in_STEM_Resources.html

Lina Stein
Elisa Coraggio,
Sebastian Gnann,
Melike Kiraz,
Dr Valentina Noacco,
Dr Francesca Pianosi,
Dr Maria Pregnolato
Lina Wang
Department of Civil Engineering, University of Bristol

Events Calendar 2019

Date	*TITLE*	*Venue*	*Type*
24 June	CELEBRATING HYDROMETRY Joint BHS/CIWEM meeting	ICE London	National
25 June	Temporary Rivers and Streams Workshop	Nottingham Trent Uni	National
25-31 July	INQUA 2019	Dublin	International
12-13 Sept	4th IMA Int. Conference on Flood Risk	Swansea	International

A new vision and road map for flood hydrology

The Environment Agency is leading the development of a road map for the flood hydrology community in the UK, to outline a future vision for flood hydrology and agree on prioritised actions and research needs to move us towards that vision.

This vision covers both forecasting and flood estimation.

We started by collecting ideas from around 240 people from 50 organisations or teams and we now want to open this up further to get your feedback and input.

We have drafted a vision and lists of potential work areas for you to comment on under four sub-themes:

We want to hear from you!

- **Ways of working in flood hydrology**
- **Methods in flood hydrology**
- **Data for flood hydrology**
- **Scientific Understanding of flood hydrology**

You can contribute via this survey

httpswww.smartsurvey.co.uksFloodHydrology

The survey will be open from **30th April until 19th May**.

Who is involved?

Although this is EA-led, it is for all of us. We would like input from as many different voices as possible.

The EA works for England. We are working with NRW, SEPA and Northern Ireland Rivers Agency and hope by working with the right people, some of the outputs will also be useful more widely across the UK.

For more information about the initiative, please contact Anita.Asadullah@environment-agency.gov.uk before June Michael.Vaughan@environment-agency.gov.uk from June onwards.

Good home required

The Canal & River Trust Water Management team are in possession of a new and unused "Braystoke model 001" Flowmeter Wading Set, manufactured by Valeport. This open channel large impellor flowmeter set is surplus to the Trust's requirements and we are seeking a suitable home for the instrument. Specifications can be found on Valeport's website and a more detailed description can be found on Valeport's website in PDF format. The Trust is keen that the instrument finds a good home, preferably a UK-based charitable or educational organisation, where it will be certain to have plenty of regular use and will be of benefit, either for research/monitoring projects or perhaps for training flow gauging techniques.

Please contact water.information@canalrivertrust.org.uk to register your interest and discuss further.

Model 001 & 002 Open Channel Flow Meters

The Valeport 'Braystoke Model 001 and Model 002 flow meters provide a cost effective and reliable method of monitoring flow in a variety of environments, including salt, fresh and effluent water, from shallow streams to tidal waterways.

The meters benefit from the design of the impeller bearings, which give low threshold velocity and consistent performance.Their ease of operation makes the 001 and 002 ideal for field study use and an invaluable tool for hydrometric work.

Available as either a wading or suspecisonset,, all systems are supplied with the Model 0012B real time control display unit.

UK Hydrological Bulletin: February – April 2019

The UK climate is inherently variable but weather patterns through the early months of 2019 have been especially capricious with large spatial and temporal variations in both rainfall patterns and in river flows. A number of notable flood interludes, culminating in mid-March, contrasted with seasonally depressed river flows and groundwater levels — in eastern Britain particularly. For the UK as a whole, the May 2018 to February 2019 rainfall was the second lowest (for that 10-month timespan) since 1972/73. Fortunately in a water resources context, March precipitation was the highest for twenty years at the national scale. This provided a very timely boost to reservoir stocks across much of the country and, in many areas, provided impetus to the seasonal recovery in groundwater levels. April was exceptionally mild with seasonally high evaporative demands — the latter restricting groundwater recharge particularly in eastern England where, in the absence of exceptional May rainfall, very moderate summer flows may be anticipated in spring-fed rivers and streams.

A wintry start to February was accompanied by significant snowfall across most of the country. Subsequently, very mild conditions prevailed: for the UK it was the second warmest February on record. A cyclonic episode, culminating on the 9th (when a 48-hr rainfall total of 82 mm was recorded at Shap, Cumbria), triggered a steep recovery in river flows (see Fig 1). Flood alerts were widespread, from central Scotland to South East England. A continental high pressure cell then extended westwards bringing notably dry and mild conditions. As a consequence, both evaporation demands and soil moisture deficits were well above the seasonal average. One consequence was a notable decline in river flows; month-end outflows from Great Britain were the second lowest since 2003. Particularly low flows characterised rivers in south-east Scotland and north-east England where January–February runoff for the River Coquet eclipsed the previous minimum in a series from 1964. This, together with notable rainfall deficiencies over the May 2018-February 2019 period and the delayed recoveries in groundwater levels in much of southern and eastern England, resulted in some concern for the water resources outlook.

A major synoptic change in early March heralded a notably wet fortnight, particularly in Wales, northern England, southern Scotland and, especially, Northern Ireland where the previous maximum March rainfall total (in a series from 1910) was eclipsed.

A sequence of deep Atlantic low pressure systems crossed the country resulting in very large rainfall accumulations in, mostly, western areas. In mid-month a five-day rainfall total of 264 mm was recorded at Capel Curig in north Wales. Correspondingly, flood alerts were widespread and, in Northern Ireland, several rivers registered more than twice their average March runoff, such that for the river Mourne the previous maximum runoff for March, in a series from 1982, was eclipsed.

Daily outflows from the UK as a whole also exceeded the previous maximum for mid-March but subsequent recessions were very steep as

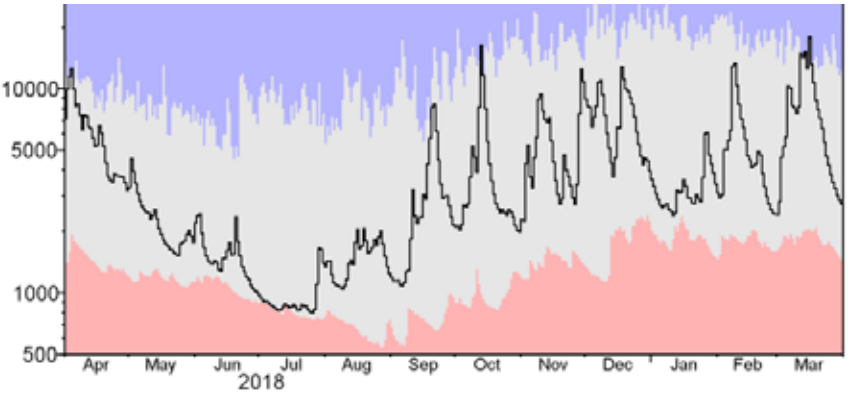

Fig 1 Daily outflows (m^3s^{-1}) from Great Britain (black trace), the blue and pink envelopes are the daily max. and min. flows in a series from 1961

much of the country registered virtually no rainfall over the last fortnight. Consequently, many rivers in southern England and East Anglia reported well below average flows and groundwater level recoveries had yet to gather any momentum across much of the slower-responding Chalk outcrop

Entering April, and notwithstanding below average rainfall over the winter half-year, estimated overall reservoir stocks for England & Wales were marginally above average for the time of year. Stocks in almost all index reservoirs were within 15% of capacity; Roadford in Devon was a significant exception.

Groundwater levels in wells and boreholes exhibited large regional and more local contrasts — reflecting differences in rainfall patterns and the responsiveness of individual aquifer units. Exceptionally high levels characterised the Permo-Triassic sandstones of south-west

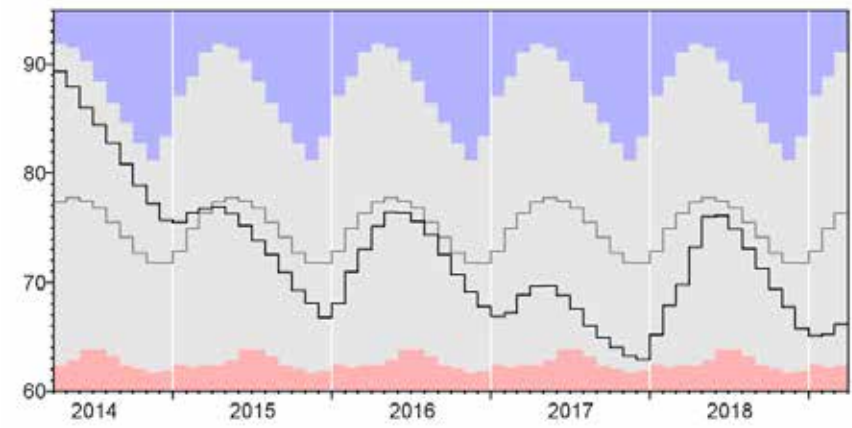

Fig 2 Monthly groundwater levels (black trace) for the Stonor (Oxfordshire) well in the Chalk of the Chilterns. The blue and pink envelopes are the max. and min. monthly levels and the grey trace in the long term monthly average

Scotland whilst, in contrast, levels in some eastern and southern Chalk wells and boreholes remained depressed; at Dial Farm (Suffolk) levels were the lowest for mid-spring for twenty years.

After an unsettled first week, with significant snowfall on northern hills — meltwaters contributing to spates in Scotland particularly — high pressure centred over Scandinavia dominated synoptic patterns bringing seasonally cold and dry conditions across the UK; thence succeeded by very warm conditions over the Easter period. Flow recessions became re-established and were of most concern in groundwater-fed streams in eastern England where well above average soil moisture deficits are likely to delay any sustained recovery until the autumn.

Terry Marsh
25/4/19

New members

Richard Laker .....Dudley
Francis Quail .....Glasgow
GarethDavis.....Environment Agency, Exeter
Racquel Moore .....Brett Consulting Limited Reading
Jack Dudman .....JBA Consulting, Warrington
Kartheepan Sivak.....Sutton
Philip Crawford .....Jacobs Uk Ltd, Leeds
StefanLe Roy .....Wsp Reading
Tim Mcgrath.....The Wildfowl & Wetlands Trust, Gloucester
Bethan Parker.....Dwr Cymru/ Welsh Water, Swansea
Charles Rouge .....SheffieldUniversity
Emma Serjeant .....KRS Environmental Ltd, Montgomery
Ross Ewart .....Arcus Consultancy Services, Glasgow
Hanna Landquist .....JBA Consulting, Stockport
Edward Balls .....Chelmsford
Kerryn Hockley .....Environment Agency, Bodmin
Jonathan Page .....King's Lynn
Cameron Ray.....Bedford
Johannes Senn ..... Newcastle University
Priyanka Sarkar .....Assam Central University, India
Melike Kiraz .....Bristol University
Sebastian Gnann ..... Bristol University
Eva Loerke .....Aberdeen University
Callum Pearson .....Durham University

British Hydrological Society,
JBA Trust
Environment Agency

MSc Studentship Award Scheme 2019

This award scheme supports talented students wishing to pursue development of their academic experience and qualifications in hydrology, water resources and catchment management. Graduates of MSc courses play a vital part in the future management of the water environment and in the progressive development of academic expertise in hydrology

The studentships will be awarded to a small number of students to help towards Master's degree tuition costs at UK Higher Education Institutions. Awards are anticipated to be between £1,500 and £2,500 depending on the number and quality of applicants.

Applications should be made using the dedicated online application website:

http://bhs-studentships.jbatrust.org/Welcome.aspx
The closing date for application is 15 July 2019.

We strongly advise all applicants to read the notes on award elegibility before starting the application process.

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