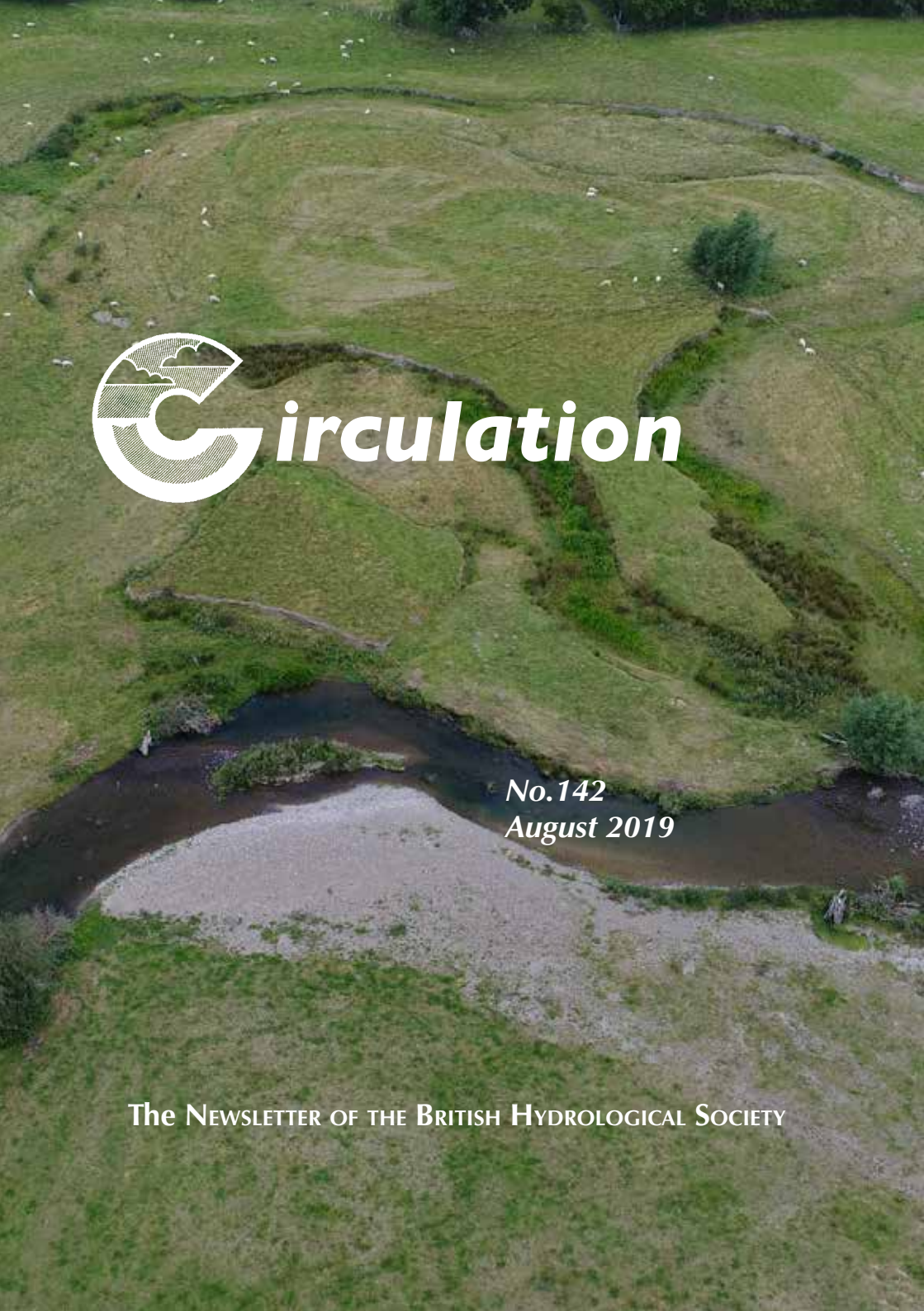


Circulation

No.142
August 2019

The Newsletter of the British Hydrological Society

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Copy deadline for Circulation No. 143 31st October 2019

As from the next issue of *Circulation* (No. 143), on-line copies will not be available until the seond week in the month and print copies will reach members a few days later.

This is to allow Terry Marsh sufficient time for the review of the last quarter's hydrological summary to incorporate complete recorded data (not last-minute phone calls to key stations in order to meet the existing print dead-line).

And while we have all been swapping stories on recent weather issues, Terry tells me that 38.6°C was recorded at CEH Wallingford but that'll not be as enduring a record at the –18.3°C minimum recorded in the early 1980s.

Editor

Cover picture: River Teme in Herefordshire, taken in 2017 using a DJI Phantom 4 Pro drone

© *Amy Woodget*

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- **Membership enquiries: Moira Doherty, BHS Secretary, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA. Tel: 0207 665 2234 Email: bhs@ice.org.uk**
- **Editor: Celia Kirby Tel: 01544 230053 Email celia.kirby@btinternet.com**
- **Web pages: http://www.hydrology.org.uk/**

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President's Piece

The Queen's Birthday Honours in June included two former members of the BHS Main Committee. Of course they were not honoured for their committee work (!) but it is very good to see national recognition for work done by our members. If you are aware of any other relevant honours or awards do please contact the Editor so that they can be marked in *Circulation*.

Speaking of the committee, we had a very good response to the request for nominations and you have the opportunity to vote for the two new committee members who will take up their positions in the autumn. The committee set-up is such that vacancies arise every year, so I hope that those who are not successful this time will consider the opportunity in a future year. There is no need for an election for the Honorary Treasurer position as we had just one nomination. I should like to take this opportunity to thank Ian Littlewood for his significant contribution to the Society, particularly in that role over the past two years, but not forgetting his earlier stint on the committee or his important work as the first BHS Editor of our journal *Hydrology Research*.

One of Ian's contributions has been to bring greater rigour to the procedures for two of the ways in which we use Society resources (which of course substantially means your membership subscriptions). These are the studentship scheme that provides bursaries for MSc students (with grateful thanks to our partners in the scheme, the JBA Trust and the Environment Agency) and our awards to support conference attendance. Whilst there are no defined age limits, both of these schemes primarily support younger hydrologists who we hope will play their part in taking both the Society and the science of hydrology forward in years to come.

In the last issue I wrote about the varying fortunes of the BHS regions. At the time we had not completed the protracted negotiations with ICE about data protection issues, but we now have access to the membership database held by ICE and have been able to produce maps showing the locations of BHS members (in the UK) and the numbers in each region – see overleaf. The regions displayed are in some cases a combination of regions defined by ICE. If anyone feels that they are in the 'wrong' region please remember that all members are welcome at any BHS event.

It doesn't seem long since I wrote the first of these articles, but quite a lot has happened, including the successful Symposium at the University of Westminster shortly after the loss of my immediate predecessor Geoff Petts. I hope that no future President (and most especially the next one!) is faced with such a situation. I think the Society is in good shape as I prepare to hand over to Nick Chappell but, as I said at that Symposium and elsewhere, the Society will only develop and thrive if members step forward and take on meeting organisation and other activities. I am writing this on the 50th anniversary of the moon landing that met President Kennedy's 1961 commitment, and to conclude I unashamedly plagiarise one of his most famous soundbites – "Ask not what your Society can do for you …."

Peter Ede
President

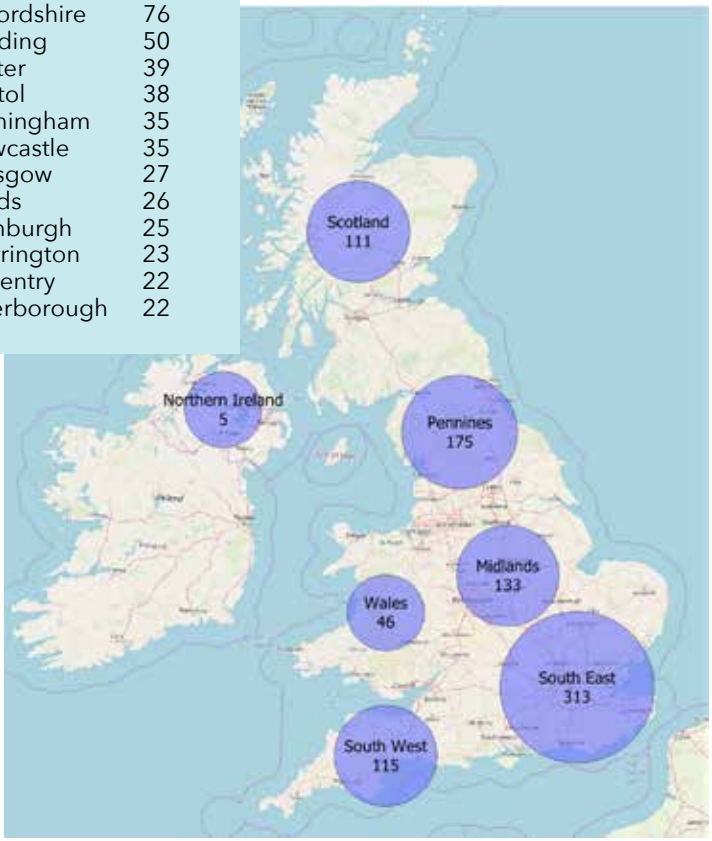
Membership statistics

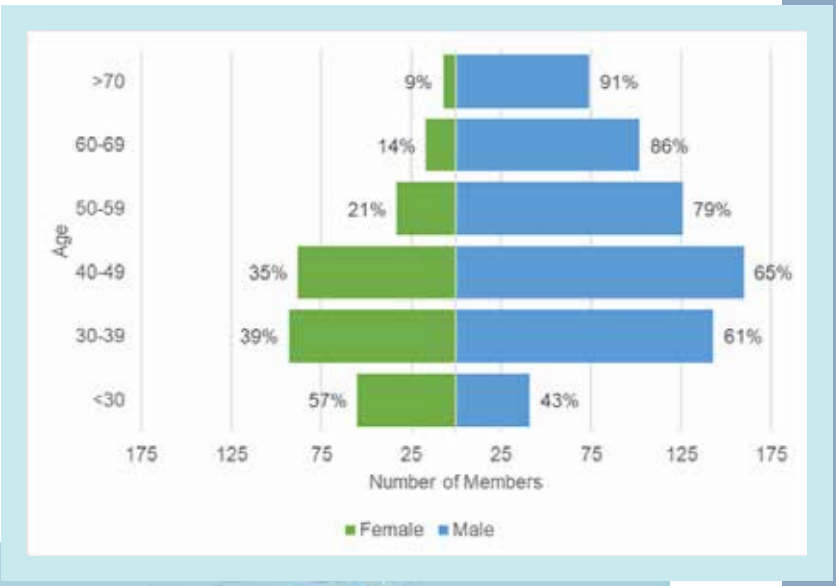
These maps give an indication of the spread of members, but can't give a full picture of the concentration of members where many have the same postcode. Unsurprisingly the Oxfordshire postcode has the largest number of members (primarily in or near Wallingford), but the table shows substantial groups of members in many other locations. However, there are areas we have yet to penetrate – 22 of the country's 121 postcode areas have no BHS members (and a further 15 just one).

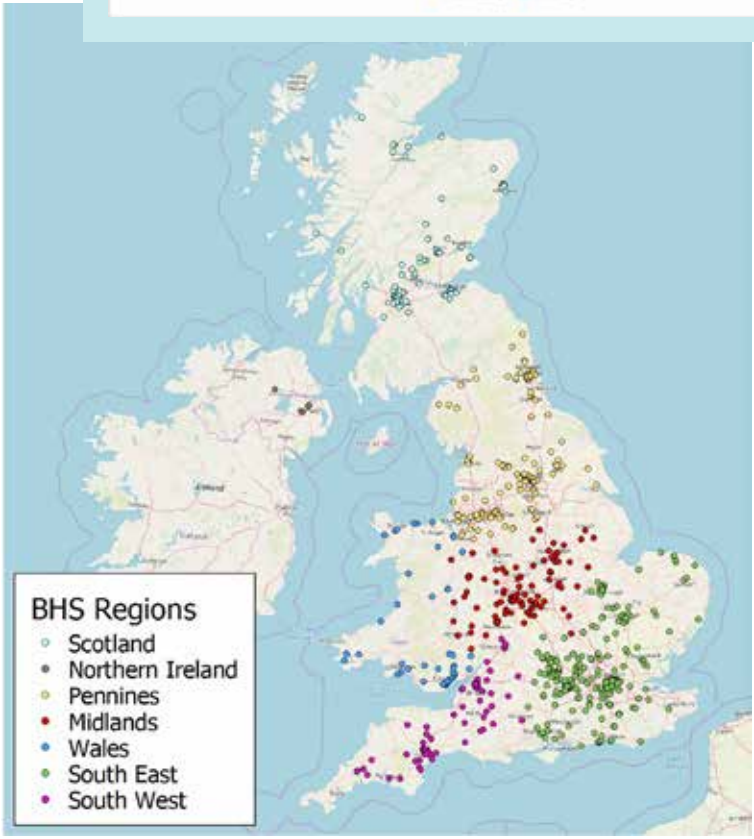
Just over 30% of our members are female, but there is distinct variation with age as shown below. In the youngest group women are in the majority; this would apply for a threshold age up to 33. On average women have been members for 11 years and men for 15 years. 8% have been members since 1983, the year that BHS was founded.

Chris Allman and Peter Ede

Postcode	*Location*	*Members*
OX	Oxfordshire	76
RG	Reading	50
EX	Exeter	39
BS	Bristol	38
B	Birmingham	35
NE	Newcastle	35
G	Glasgow	27
LS	Leeds	26
EH	Edinburgh	25
WA	Warrington	23
CV	Coventry	22
PE	Peterborough	22




>70
60-69
50-59
40-49
30-39
<30
Age
9%
91%
14%
86%
21%
79%
35%
65%
39%
61%
57%
43%
175
125
75
25
25
75
125
175
Number of Members
Female
Male


BHS Regions
Scotland
Northern Ireland
Pennines
Midlands
Wales
South East
South West

BHS Working Group on the

Future of UK Hydrological Research

Here is the report of the first meeting of this Working Group convened by Keith Beven which took place on 26th April 2019 at the Royal Society. Fifteen of the 17 members of the Working Group were present, together with a representative of the Royal Society Policy Group.

The meeting started with Keith giving some background to the initiative, including an overview of the outcomes from all the suggestions for innovation received in the bids for membership of the Working Group that followed an invitation distributed on the BHS mailing list. This list could be interpreted in terms of the state of UK Hydrology today, with many of the suggestions concerned with the limitations of current methods and techniques, without any real suggestion of how to innovate. There had been few suggestions received for research needs in snow and ice and also groundwater areas.

Keith stressed the wish to focus on how to improve the hydrological science (while recognising that there might be different requirements for different purposes) and on the longer term (10 years or more). It was noted that this BHS initiative was complementary to other efforts to look towards both the near and far future, including the EA Flood Road Map, the HydroJules project, and the IAHS Unsolved Problems in Hydrology review.

Following this brief review of the current state of UK Hydrology, the morning discussions were wide ranging but included the question of whether it was possible to make full use of all the current knowledge and data that could be available. This could be because of data availability (not all historical data is readily available and some may be already lost); open data and the commercial-in-confidence constraints; lack of metadata about sources, quality assurance and uncertainties associated with the data; also the sheer quantities of some types of big data and the impossibility of assessing the vast number of publications and reports. Further, Hydrology is not just a science depending on data, but also depending on experience, which is hard to pass on within a community.

It was also noted that we continue to be in a situation where it is still not easy to create a robust water balance for a catchment (or even a smaller landscape unit) when all the fundamental terms might be subject to difficult to characterise knowledge uncertainties. Rain and snow inputs

remain a particular difficulty in many situations, together with flood peak and drought affected discharges. This then creates difficulties for the assessment of historical conditions as well as of change as a result of either land management or climate, including the extremes that are so important for hydrological systems. The problems get worse when we are not just interested in water alone but in the residence and transit times of that water and how that might affect biogeochemistry and water quality dynamics. Improving the understanding and representation of both water flow and transit times in a variety of circumstances would still require some improvements in both measurements and models. It is also speculated that there may be tipping points in the hydrological and biogeochemical systems induced by change; the question of whether such tipping points can be identified or predicted remains open.

The afternoon was taken up with a discussion of what were the most important issues in making real progress in the understanding of hydrological processes and the testing of models representing that understanding (which might in themselves require some theoretical progress in addressing, for example, scale and commensurability issues in flow and transport representations and parameters). There was some discussion of what the drivers (the why?) and enabling mechanisms (the how?) might be for different types of innovation. Much of the discussion was concerned with observational needs: what might be needed; why was it needed; to what level of accuracy; and how might that be achieved?

The final discussions were concerned with involving and getting input from the wider hydrological community (and potential links to other communities). It was agreed that the process should be as open as possible, with the expectation that some small teams might be formed to prepare functional requirement and justification documents and take them forward. This might also mean using models to demonstrate theoretically what could be achieved if new observational techniques could be made available, relative to what could be achieved with current data; including some economic assessments of costs and benefits where appropriate.

A full report of the meeting, including a summary of all the suggestions for future research priorities received from the community, plus a set of potential priority topics, can be found on the BHS Future Hydrological Sciences web page **http://www.hydrology.org.uk/bhs-working-group-future.php**. If anyone is interested in being involved in this process for one of the priority areas identified, please record your interest through this BHS web page.

Keith Beven (with input from several WG members)

The 3-parameter distribution as an alternative for use with FEH pooling groups

Thomas Rodding Kjeldsen

This note introduces a new three-parameter distribution, KAP3, for use within the FEH statistical method as an alternative to the GLO and GEV distributions. Basic familiarity with FEH methodology and terminology is assumed.

The choice of distribution is an important part of the FEH pooling group methodology when estimating design floods in gauged and ungauged catchments. In practise the choice is based on either the Z-statistics produced by the WINFAP software, or the default recommendation of a 3-parameter Generalised Logistic (GLO) distribution. The GLO distribution was first recommended by the original Flood Estimation Handbook (FEH) published by the Institute of Hydrology (1999). This choice was confirmed by the Environment Agency (2008), and later again by Kjeldsen and Prosdocimi (2015). All three studies were based on the method of L-moments and relied on a choice between different three parameter distributions such as the GLO, the Generalised Extreme Value (GEV) or the Generalised Pareto (GPA) distributions. While all studies found the GLO distribution to be the most suitable overall, it is clear that the GEV distribution in most cases could be an equally valid choice. In fact, earlier flood studies such as the FSR developed regional growth curves based on the structure of a GEV distribution (NERC, 1975).

The goodness-of-fit test used as the basis for recommending the GLO distribution rely on the position of the higher-order L-moment ratios (L-skewness and L-kurtosis) on an L-moment diagram in relation to a set of theoretical lines representing the GLO, GEV and GPA distributions. Figure 1 shows an example of how a L-moment diagram can be used to assess the choice of distribution for use with a particular pooling group.

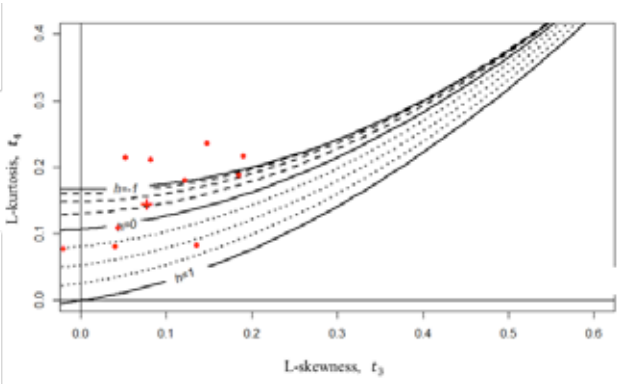


Fig 1 L-moment diagram for pooling group created for 36007 Belchamp Brook @ Bardfield Bridge. The full circles represent single site L-moment ratios for each of the 11 pooling group members, and the red cross is the pooled L-moment ratios. Grey hatched lines represent contours of the Kappa distribution for h = −0.25, −0.50 and −0.75 (dashed lines), h = 0.25, 0.50, 0.75 (dotted lines) and h = −1 (GLO), 0 (GEV), 1 (GPA) (solid lines).

A particular feature of L-moment diagrams is 3-parameter distributions are represented by lines. It is noteworthy that there is a lot of empty space on these L-moment diagrams between the theoretical lines separating the different distributions. In contrast, a 4-parameter distribution covers a 2-dimensional space on an L-moment diagram, such as the space between the GLO and GEV lines. A particular 4-parameter distribution of interest to UK flood data is the Kappa distribution (Hosking, 1994; Hosking and Wallis, 1997; Kjeldsen *et al*., 2017) which includes the GLO, GEV and GPA distributions as special cases. When using a 4=parameter Kappa distribution is defined as

$$Q(F) = \xi + \frac{\alpha}{\kappa}\left[1 - \left(\frac{1 - F^h}{h}\right)^\kappa\right] \quad (1)$$

where ξ is the location parameter, α the scale parameter, and κ the shape parameter, and h is a the 4th order parameter taking values between −1 and 1. For h=−1 the Kappa distribution reduces to a GLO distribution. For h=0 it it a GEV distribution, and for h=1 it becomes a GPA distribution. This means that contour lines of the Kappa distribution can be drawn anywhere between the GLO and the GPA lines for fixed values of h as shown in Figure 1 as grey hatched lines.

Using high-quality annual maximum series of peak flow data from 564 rural catchments, each catchment in turn was treated as being ungauged and a pooling group formed using data from the remaining 563 catchments following the procedure outlined in Environment Agency (2008) and implemented in the WINFAP software. The resulting 564 pooled estimates of L-skewness and L-kurtosis were derived by Kjeldsen *et al*. (20127) and plotted on an L-moment diagram as shown in Figure 2. What is immediately striking is that the majority of points are located in the space between the GLO and the GEV distribution lines, with no obvious eyeball reason why one distribution should dominate over another.

The four parameters of the Kappa distribution were estimated for each of the 564 pooled sets of L-moment ratios using the method of L-moments as described by Hosking and Wallis (1997). Next, the average of the resulting 564 pooled estimates of the h parameter gives a 'national average' value of h=−0.40. The Kappa contour line corresponding to the national average value of h=-0.40 is plotted on the L-moment diagram in Figure 2 as a red hatched line.

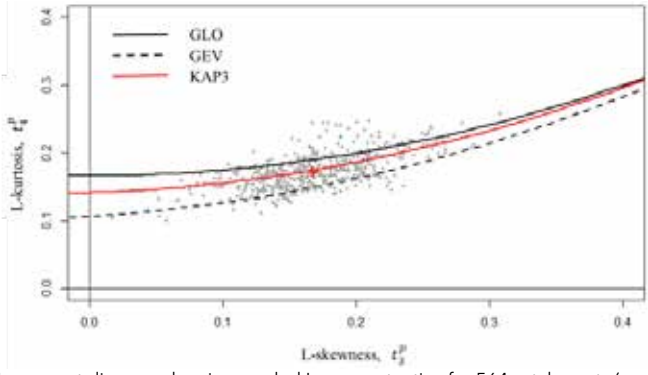


Fig 2 L-moment diagram showing pooled L-moment ratios for 564 catchments (grey dots). Red line represents contour line for Kappa distribution with national average of h=-0.40.

Visually, it is clear the 3-parameter Kappa distribution (KAP3) provides a visually more satisfactory fit to the observed behaviour of the pooled L-moment ratios. This conclusion was confirmed using more formal statistical goodness-of-fit tests by Kjeldsen *et al*. (2017). They reported that the proposed KAP3 distribution was an acceptable distribution for 90% of pooling groups, while the GLO and GEV distributions were each acceptable for 74% and 79% of pooling groups, thus a clear improvement over the existing procedures.

Using the Kappa distribution within FEH

This section derives the new equations necessary to use the KAP3 distribution within the FEH methodology, where location parameter is defined by the median.

Definition of flood frequency and growth curve

Following the notation introduced in the FEH Vol. 3, Chapter 15, the T-year event of the Kappa distribution is defined as

$$Q(F) = \xi + \frac{\alpha}{\kappa}\left[1 - \left(\frac{1 - F^h}{h}\right)^\kappa\right] \quad (1)$$

where ξ is the location parameter, α the scale parameter, and κ the shape parameter. For the proposed national KAP3 distribution, the fourth parameter is fixed at a 'national average' value of h=−0.40 based on the above data analysis.

The Kappa distribution is defined for h<0 and -1<h<-1/h and the range of possible values are defined as

$$-\infty \le Q \le \xi + \frac{\alpha}{\kappa} \quad \text{for } \kappa > 0,\ h \le 0 \text{ (bounded above)}$$

$$\xi + \frac{\alpha}{\kappa} \le Q \le \infty \quad \text{for } \kappa < 0,\ h \le 0 \text{ (unbounded above)}$$

$$-\infty \le Q \le \infty \quad \text{for } \kappa = 0,\ h \le 0 \text{ (unbounded above)}$$

The median (QMED) of the Kappa distribution is defined as Q(F=0.5)

$$QMED = \xi + \frac{\alpha}{\kappa}\left[1 - \left(\frac{1 - 0.50^h}{h}\right)^\kappa\right]$$

which for h=-0.40 reduces to

$$QMED = \xi + \frac{\alpha}{\kappa}[1 - (\ln 2.22)^\kappa] \quad (2)$$

The growth curve $x(F)$ is defined through the index-flood method Q(F)=QMED×x(F), and for the KAP3 distribution can be found by combining Eqs. (1) and (2) as

$$x(F) = 1 + \frac{\beta}{\kappa}\left((\ln 2.22)^k - \left(\frac{1 - 0.50^h}{h}\right)^\kappa\right)$$

where the new scale β is defined as

$$\beta = \frac{\alpha}{\xi + \frac{\alpha}{\kappa}[1 - (\ln 2.22)^\kappa]}$$

The growth curve is more conveniently expressed using return period T using the transformation $F = (T-1/T$, i.e.:

$$x_T = 1 + \frac{\beta}{\kappa}\left((\ln 2.22)^k - \left(\frac{1-\left(\frac{T-1}{T}\right)^h}{h}\right)^\kappa\right)$$

Growth curve estimation

First the shape parameter κ is estimated by finding the value of κ that solves the equation

$$\frac{(-g_1 + 3g_2 - 2g_3)}{g_1 - g_2} - t_3 = 0 \qquad (3)$$

where t_3 is the L-skewness of the AMAX data (or a pooled estimate t_3^P), and the function g_r defined according to Hosking and Wallis (1997) as

$$g_r = \frac{r\Gamma(1+\kappa)\Gamma(-\kappa - r/h)}{(-h)^{1+\kappa}\Gamma(1-r/h)}, \qquad h < 0 \qquad (4)$$

The solution to Eq. (3) can be found using, for example, the Newton-Raphson method, or simply the solver function in EXCEL or any other numerical software. The solution is the value of κ that solves Eq. (3) for a given value of t_3.

Next, the new scale parameter β can be estimated as

$$\beta = \frac{t_2\kappa}{(g_1 - g_2) + t_2(g_1 - (\ln 2.22)^k)} \qquad (5)$$

where t_2 is the L-CV of the AMAX data (or a pooled estimate t_3^P), κ is the solution to Eq. (3) and g_1 and g_2 calculated from Eq. (5) using the estimated value of κ from Eq. (3).

Finally, *QMED* is the median of the AMAX data, or is estimated from catchment descriptors.

Example: 53018 River Avon @ Bathford

This example uses the KAP3 in a single-site analysis. The NRFA peak flow dataset has good quality AMAX data available for the river Avon @ Bathford covering a n=40 year period including the water years 1969–2008. The L-moment ratios for this AMAX series are: t_2=0.130, and t_3=0.034. Estimators for scale β and shape parameter κ listed in the FEH Vol.3 for the GLO (section 15.3.3) and GEV (section 15.4.3) as well as Eqs. (5) and (3) above for the KAP 3 distribution were used; the results are shown in Table 1.

Table 1 Comparison of FEH distribution parameters for the GLO, KAP3 and GEV distributions.

Distribution	QMED (m^3/s)	β	κ
GLO	168.6	0.1307	–0.0336
KAP3	168.6	0.1705	0.0845
GEV	168.6	0.2241	0.2252

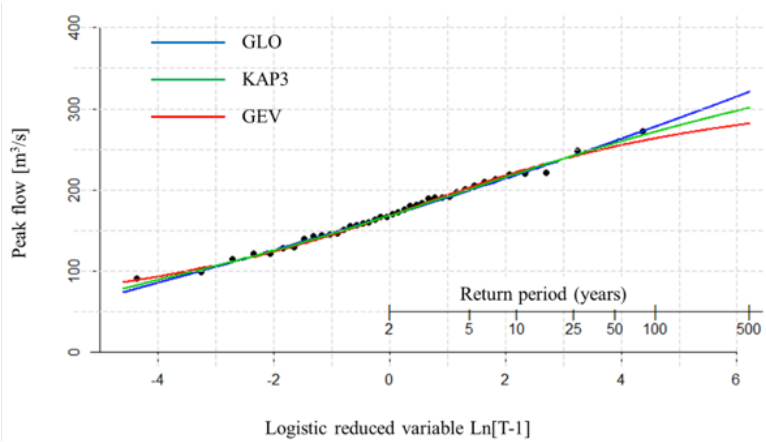


Fig 3 Comparison of flood frequency curves for single site analysis of AMAX data from gauging station 53018 Avon @ Bathford.

Figure 3 shows a comparison between the three flood frequency curves (GLO, KAP3, GEV). The plot shows that for this station the KAP3 distribution falls in between the GLO and GEV distributions.

Analysing the pooled flood frequency curves for 564 rural gauging stations, Kjeldsen *et al*. (2017) found that, in general, the KAP3 distribution will result in 100-year design flood events that are between 1% and 4% Lower than the corresponding design events estimated for the same pooling group using the GLO distribution. In contrast, KAP3 design estimates were in the range 2–5% larger than design events estimated using the GEV distribution. Therefore, the benefit of having a distribution more closely matching the pattern observed in the observed flood data (KAP3) should be weighed against an anticipated slight decrease in the magnitude of design events.

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Thomas Rodding Kjeldsen
Department of Architecture and Civil Engineering, University of Bath, BA2 7AY, Bath, UK.
t.r.kjeldsen@bath.ac.uk

Nick Chappell – President-elect



"I began my hydrological career in 1987 with a year of fieldwork on the Plynlimon massif in mid-Wales with an with an interest in hydrological modelling beginning the following year after six months at the University of Georgia's School of Forestry (USA). I than became a lecturer at the School of Geography, University of Manchester and started a long-term focus on tropical forest hydrology, in collaboration with Ian Douglas and Malaysian scientists working at Yayasan Sabah's Danum Valley research station in Malaysian Borneo."

A year later, Nick started his lectureship at Lancaster University, teaching water supply and hydrological processes. New experimental catchment work in Northwest England for UK Nirex began in collaboration with Keith Beven and partners at Newcastle University and Imperial College London. The tropical research on fundamental hydrological processes and ways of quantifying measures to mitigate the hydrological effects of commercial forestry continued to develop. First via wider collaboration with tropical hydrology gurus such as Sampurno Bruijnzeel (Vrije Universiteit Amsterdam, now Kings College London) and Mike Bonell (UNESCO IHP). Secondly via 14 years serving on the Royal Society Rainforest Research Committee. Lastly, via wider international partnership research with scientists from for example Japan, Thailand, Singapore, Ghana, USA, Papua New Guinea, India and most recently Brazil and Argentina.

"The recent extreme floods in the UK prompted government, NGOs and the public to consider the potential value of trees and other hydrological modifications to agricultural land to help reduce the risks to flood-affected communities. I have been able to contribute to the assessment of the effectiveness of these so-called 'natural flood management' interventions by leading one of the three national projects funded by UKRI. These projects are working closely with the Environment Agency's own NFM pilots.

Throughout, I have maintained a commitment to teaching hydrological science at undergraduate and postgraduate level, including administration of the postgraduate training programmes in Sustainable Water Management and Flood & Coastal Risk Management (FCRM), taught jointly with industry partner JBA Consulting, with inputs from CEH Lancaster and the Environment Agency.

I am very much looking forward to helping maintain BHS's leading role in promoting research in hydrological processes, innovative engineering practice and critically, the career development of the next generation of hydrologists in the UK, building on the inspired and effective leadership of Peter Ede, with the invaluable support of the committee and our membership."

Flood Forecasting: Developments in Science and Application



The 2008 Pitt Review was one of the widest ranging policy reviews ever carried out in the UK and resulted in the establishment of the Flood Forecasting Centre, with forecasting products now being issued to a range of stakeholders. Agencies responsible for flood forecasting across the UK and Ireland have advanced real-time modelling applications to support the growing need for early warning services which has in turn seen a significan improvement in flood resilience.

Ongoing challenges remain for flood forecasters, including the prediction of flash flooding. Research such as the jointly funded Natural Environment Research Council and Met Office Flooding from Intense Rainfal programme has looked to seek ways of improving forecasts of such events and scoping end-to-end forecasts. Other recent developments include how to handle forecast uncertainty, with growing application of probabilistic forecasting.

This BHS National Meeting will bring together those involved in developing the science and its application and will look at how we are making more use of flood forecasts.

Venue: One Great George Street, London

Registration opening soon.

1st October 2019



Image source: Flood Forecasting Centre

British Hydrological Society

Dear Editor

Recently *Circulation* reported on a meeting about Quality though Equality, and tackling gender issues.

Our President, Peter Ede, is right — in time the older cohort of hydrologists will include far more women. The law of conservation of mass implies you cannot suddenly, instantly, magic up a crop of old women hydrologists to match the number of old men hydrologists.

The advice given by Prof. Cloke, "especially [for] women or members of ethnic minorities" is, in my experience, applicable to everyone. Equality of opportunity and fairness should apply across the population, and not just single out women. Indeed most of the points made in this interesting article applies to everyone, again not just women.

We should encourage anyone into science, people of whatever gender, from what ever background and make them all feel welcomed and valued. A difficulty is perhaps a mismatch between the perceptions of what people expect from their employers, and what employers are able to offer.

John Mosedale
The Dwindling Association
of Old and Grey
Male Hydrologists

New members

Gareth McShane.....University of Lancaster
Douglas Coyle.....Brampton
Sam Everitt.....Environment Agency, Farnham
Jack Maunder...Environment Agency, Blandford Forum
Louise M Parry.....Ove Arup & Partners Ltd, Leeds
Catherine E Jeffries....Environment Agency,Shrewsbury
Kathryn Hooley.....Arcadis Consulting Ltd, St. Mellons
Adam Bushnell.....Stafford
Sarah Coleman.....Newtownards
Said Shenwari.....University of Lancaster
Josh Wolstenholme..... ...University of Hull
Katherine Rushen.....Colhester
E. Strathdee.....University of Bristol

Peter Wolf Symposium

Sadly, we have had to postpone this event for 2019 and are re-scheduling it for next year. Full details will be announced widely when new dates are finalised.



8–10 September 2020
Lancaster University, UK

Call for session proposals

We invite you to propose one or more sessions for the next British Hydrological Society biennial symposium to be held at Lancaster University from Tues 8th to Thurs 10th Sept 2020. Your session may be on any topic of relevance to part of the BHS community, whether studying or working within consultancies, government, research organisations, water companies or academia, or those bridging disciplines, e.g., aquatic biogeochemists, aquatic ecologists, hydro-climatologists, hydro-geomorphologists, soil scientists, etc. We are open to creative session formats (e.g., demonstrations, debates, interactive multi-media etc.) in addition to the various formats of oral presentations and posters. Equally, we welcome originality and diversity in session topics. For example, you might focus on:

- contributions from an exciting new or nearly complete UKRI research programme(s)
- ongoing initiatives or future needs of regulatory agencies (e.g., EA Roadmap for flooding, 25-year Environment Plan)
- demonstrations of new technology
- new teaching/training approaches
- topics particularly pertinent to early career hydrologists
- the BHS Future of Hydrology initiative
- an externally-sponsored session
- ways of promoting UK hydrological expertise overseas (research or practice)
- solutions to particularly challenging engineering problems
- tapping the expertise of retired hydrologists etc. etc.

Please submit your session proposals on the simple MS-Word form available from the BHS website:
http://www.hydrology.org.uk/news/php by Fri 22 Nov 2019.

If you have ideas for social activities that you would like to see at BHS2020 please also use the final section of this form to submit. Any questions regarding your session ideas, please ask local organisers

Nick Chappell or **Keith Beven** via **bhs2020@lancaster.ac.uk**.

NRFA visit the Scottish Environment Protection Agency

The National River Flow Archive team went *en masse* up to Scotland in May to visit the Scottish Environment Protection Agency (SEPA) earlier in May. On the first day there was a meeting with SEPA's senior Hydrometry staff, before splitting up to visit the three SEPA areas for independent liaison visits.

The overall purpose of this Hydrometry meeting was to better understand each other's goals, exchange information, review SEPA performance and identify future opportunities. For the NRFA, the day ended with a visit to the gauging station on the River Braan at Hermitage, the Black Linn Falls and Ossian's Hall.

During the liaison visit that followed, Adam Griffin and Cath Sefton met SEPA South hydrometry staff in Lanarkshire who took them to visit gauging stations in the surrounding area on and around the Kelvin and the Clyde. The lack of rain and low groundwater levels were evident in low river flows. Cath and Adam also visited a new candidate station at Abington on the upper Clyde, which is ready to be added to the archive.

Katie Muchan visited SEPA East, meeting staff from each of the three offices (Aberdeen, Perth and Edinburgh). The first day focused on the south and west of the area, including visits to stations in the Clyde and Earn catchments, and the second day on the north of the area in the North Esk and South Esk catchment, including a new station which is ready to be added to the NRFA. It was interesting to visit two stations affected by flood alleviation scheme construction which is becoming more prevalent in the East area.

Steve Turner visited the SEPA North team in Dingwall and Elgin. Station visits went north of the Cairngorms and into the Highlands, taking in



NRFA and SEPa team visit Hermitage gauging station



North Usk at Logie Mill gauging station

a mixture of small and large, predominantly rural catchments, with most stations at relatively normal flows, although rising due to inclement weather. It was particularly useful to hear about the effects of ice dams, how hydro-electric schemes and lochs affect the hydrometry of the area, and to see a couple of new stations that will be added to the archive in the not so distant future.

Such visits allow the NRFA's Regional Representatives to update their knowledge of current equipment, processes and problems at each site, giving them a better understanding of how the river flows are measured. This information underpins the quality control of data submitted to the archive and allows metadata updates to inform the user community of new and emerging issues which should be considered when analysing NRFA data. The NRFA aims to conduct between 2–4 measuring authority liaison visits a year across the UK's 24 regional hydrometric data providers.

SEPA's Grant Kennedy acknowledged how the increasing focus on real-time data made it especially valuable to remind ourselves of the long term strategic purpose of the hydrometric network and the importance of the quality control and UK consistency that the NRFA provides. The Liaison visits were also an efficient way for the NRFA to gather local and updated knowledge on the network and gauging station performance, thus reducing the number of queries sent to SEPA following future data submission.

Stephen Turner



NRFA Manager Isabella Tindall acknowledging Nigel Goody's (former SEPA Hydrometry Unit Manager) long term contribution to the NRFA with a certificate of donation to *Trees for Life* to help restore the Caledonian Forest and to conserve Red Squirrels.



Jamie Hannaford explaining how the NRFA use SEPA's hydrometric data

Travel grant reports

Society for Freshwater Sciences
Salt Lake City
19–23 May 2019

My attendance at this meeting was a great experience, full of cutting-edge scientific talks and interesting people. This is one of the major conferences in freshwater ecology, with 68 sessions, more than 220 posters and 600 talks gathering scientists from all around the world.

I presented the preliminary results from my postdoc at Nottingham Trent University (NTU) during the special session: "Advancing knowledge on intermittent rivers and ephemeral streams: across disciplines and dimensions", together with my collaborators **Rachel Stubbington** (NTU) and **Judy England** (Environment Agency). My talk was about the effects of flow cessation and drying on aquatic invertebrate communities across rivers with different flow permanence regimes. With the collaboration of the Centre for Ecology & Hydrology and the Environment Agency, we collated observational flow-state and invertebrate data from 32 sites collected in seven chalk streams between 2005 and 2017.

Using the flow-state data, we then calculated a set of hydrological metrics reflecting the duration and frequency of drying events and the extent of dry reaches within the river for each site. We showed that site-specific invertebrate diversity decreased with increasing duration of drying events and increased with the time since the last drying event. The regional extent of dry reaches also increased community variability among sites, and isolated communities (i.e. located far from perennial sites) responded differently from more connected communities post-drying.

These results suggest that drying duration is a strong predictor of local invertebrate richness, which interacts with the regional extent of drying in driving community recovery after a disturbance ends. Therefore, different conservation strategies may be necessary in different parts of the river network.



My talk went well, and I got several questions and comments that made me think of the way to improve my analyses.

There were several other interesting talks in my session, such as Rachel Stubbington's talk about changes in surface and subsurface

aquatic invertebrate diversity patterns along flow permanence gradients and **Pablo Rodríguez-Lozano**'s (University of California: UC) talk about university student perceptions of intermittent rivers.

I also enjoyed other sessions such as "Towards a predictive understanding of metacommunity dynamics in freshwater ecosystems" which dealt with ideas I am very interested in developing in the future. In this session, **Albert Ruhi'**s (UC) talk on the effect of flow regime alteration on fish populations, **Kurt Anderson**'s (UC) talk on modelling metacommunity connectivity at network scale using traits were among my favourites. I also attended the many social events that allowed me to extend my professional network and chat with diverse people in a more casual environment. In summary, this conference was an amazing experience that brought me new knowledge, ideas and collaboration opportunities.

Romain Sarremejane
Nottingham Trent University
Romain.sarremejane02@ntu.ac.uk

Bathymetric UAS-SfM Change Detection:

The implications of refraction correction, water surface elevations & spatially variable error

A Report from the EGU General Assembly 2019 – Vienna, Austria

Overview

Every year, Europe's geoscience community comes together in Vienna to present and discuss their latest research findings. I was happy to be able to attend this year with financial support from the BHS. I attended numerous poster and oral sessions, took part in three short courses and presented two of my recent research projects.

The first of my projects (and focus of this report) investigates an approach for measuring bathymetric change in fluvial environments at very high spatial resolutions, using imagery acquired from drones and processed using structure from motion photogrammetry (SfM). The second project uses a similar method to quantify spatially continuous glacier melt rates at high spatial resolutions in areas of partial debris cover – a project led by Dr **Catriona Fyffe** at Northumbria University.

I have been working in the drone-SfM field for some time now, having started my PhD studies in this subject back in 2011. The technology, software and applications of this method have evolved significantly within this time and yet, in my view, there is a on-going need for rigorous, quantitative research which is aimed at improving, standardising and increasing accessibility to these approaches. Such research will enable us to unlock new understandings in relation to urgent environmental problems, such as climate change, and provide a reliable and efficient workflow for implementation by practitioners in industry.

The novelty of my most recent fluvial work centres around trying to solve two key problems:

(1) the difficulty of obtaining accurate topographic estimates in submerged areas, and (2) the need for thresholding measurements of geomorphic change in a way which is informed by knowledge of how elevation error varies spatially.

Bathymetric UAS-SfM Change Detection

Quantifying geomorphic change at fine spatial scales is important for a range of applications within river science and management, including sediment budgeting, monitoring river restorations, flood risk assessments and surveying physical habitat availability. To date however, few studies have attempted to quantify the success of the drone-SfM approach for quantifying geomorphic change, especially in the more challenging submerged parts of the river channel. Yet it is in these submerged zones where a majority of fluvial 'work' is occurring.

Within our EGU presentation (and forthcoming associated paper), we (myself, **Robin Wilson** of Southampton University and **James Dietrich** of the University of Northern Iowa) use two datasets acquired over a 650 m reach of the River Teme, UK, to address the two key problems mentioned above.

(1) We quntitatively asses tge accuracy and precision of th new methodological development for the bathymetric SfM process which focuses on exploring different methods of estimating water surface elevations. Water surface elevations are critical to bathymetric accuracy because of the reliance of Snell's Law on water depth estimations to correct for the effects of refraction. We find that our refined method of extracting water surface elevations, using statistical smoothing filters, reduces mean elevation errors in submerged areas by up to 88% and reduces the standard deviation of elevation errors by up to 41%.

The result is a method which can model topography in submerged areas of clear flowing rivers, where water depths are less than 2 m, with an accuracy of less than 3 cm and a precision of less than 13 cm. These statistics are in line with the accuracy and precision of topography estimates in exposed areas and represent a significant improvement in the initial methods proposed by our earlier work (Woodget *et al*., 2015; Dietrich, 2017).

(2) We identify the sources and impacts of spatially variable error on our ability to detect meaningful geomorphic change, including variations in elevation precision resulting from local slope, water depth, vegetation and the image acquisition and processing routines themselves. Whilst we



This is me flying the drone at Coledale in the Lake District in early July.

find no strong linear correlation between individual variables and topographic error, we pioneer a novel approach to error prediction using machine learning.

Initial results indicate that we are able to predict topographic error in three classes with an accuracy of 76% but this figure degrades when the number of classes is increased. We hope that on-going research in this area will help to further refine our approach and lead to an accurate and reliable means of thresholding geomorphic change in SfM models, in both fluvial settings and beyond.

We hope to publish this work soon and would like to thank the BHS for their support which enabled the first presentation of this work to a wider audience. It provoked some excellent discussions which will undoubtedly improve and inform our research going forward. We welcome any comments or questions from the BHS community on the themes discussed within this report.

Dr Amy Woodget
Independent Research Fellow,
Loughborough University, UK
www.lboro.ac.uk/departments/geography/staff/amy-woodget/
a.woodget@lboro.ac.uk

Study online for a CPD award in Water Management this September

The University of Highlands and Islands' Centre for Mountain Studies will be running an online continuing professional development (CPD) course in water management this September. In its third year as a CPD award, the 12-week course is aimed at staff employed either directly by, or as consultants to, water-related industries such as hydropower, public water supply and agriculture. It is particularly suitable for those employed as environmental managers and technical staff such as hydrologists and environmental scientists.

The course explores concepts of sustainable water management from both scientific and regulatory perspectives, including case studies on how the needs of the water user can be met without compromising the benefits that a healthy water environment provides our society both now and in the future as we adapt to a changing climate.

This module is delivered fully online and is based around a weekly presentation posted on the virtual learning environment along with accompanying learning resources such as peer-reviewed papers and web links. The course also uses web resources, such as YouTube videos and interactive web sites, for extracting and analysing environmental data.

Entry requirements are an undergraduate degree in a relevant subject although other qualifications will be considered for those with a minimum of three years relevant professional experience.

More information on what the course entails and how to apply can be found at:
https://www.uhi.ac.uk/en/courses/cpd-award-water-management/#applynow

UK Hydrological Bulletin: May – July 2019

The capricious nature of the UK climate was underlined through the late spring and early summer of 2019 which was characterised by exceptional spatial and temporal variations in rainfall and runoff. Well below average rainfall in April and May resulted in outflows from Great Britain approaching the lowest on record for early June (Fig. 1) – triggering drought concerns in some groundwater-fed streams and rivers, and agricultural stress, particularly across the English Lowlands where soil moisture deficits were substantially above average. A major synoptic change then heralded a dramatic runoff recovery with widespread, locally severe, flooding in mid-June and a seasonally unusual replenishment of reservoir stocks together with modest recoveries in some groundwater levels. For much of July, the normal north-west/south-east rainfall gradient across the UK was exaggerated as frontal systems favoured tracks across Scotland. To the south, record temperatures were recorded in a brief heatwave during the final week before thunderstorms contributed to a widespread risk of flooding. The associated increased runoff ensured that some reservoir stocks were generally a little above the average for early August.

At the national scale, May rainfall was appreciably below average for the fourth successive year but seasonally wet conditions in eastern Scotland contrasted with only around half of the average rainfall across much of southern Britain where significant deficiencies could be traced back to the early summer of 2018. For the Anglian region, such deficiencies could be expected around once every twenty years on average. The associated dry soil conditions added to agricultural stress as stocks in farm reservoirs dwindled. It was also expected to signal an end to the 2018/19 recharge season across most major aquifers (but see below).

At month-end, runoff from Great Britain approached the lowest on record for the late spring (Fig. 1) and soil moisture deficits were generally well above average. With overall reservoir stocks for England & Wales modestly below average

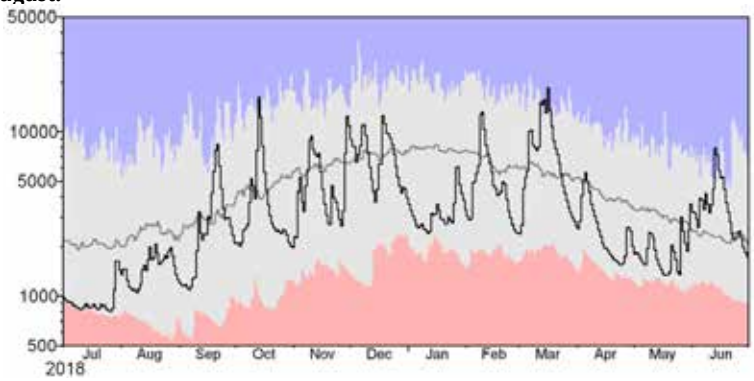


Fig 1 Daily outflows from Great Britain (m^3s^{-1}) – black trace. The blue and pink envelopes are daily maximum and minimum for the 1961--018 period; the grey trace is the daily average.

and late-May groundwater levels, in parts of East Anglia particularly, being at their lowest since 1997 the developing drought conditions became a concern. A mitigating factor was the generally healthy reservoir storage, most major impoundments being within 10% of the late-spring average.

June was a remarkable month in hydrological terms. An unusually persistent synoptic pattern resulted in a sequence of slow-moving low pressure systems crossing the southern half of the country. Many central areas registered more than twice the average June rainfall; for Wales it was the fourth wettest June in a series from 1910. Generally, runoff rates increased sharply across much of the UK. On the 4th, the river Mourne (Northern Ireland) recorded its 2nd highest June flow in a series from 1982. Flooding became extensive during the second week when three-day rainfall accumulations exceeded 75 mm over substantial areas (Fig. 2). In Wainfleet (Lincolnshire), a 48-hour rainfall total of 98 mm caused the river Steeping to break its banks; around 100 residents were evacuated. Flood Warnings were extensive by mid-month and outflows from Britain as a whole were the highest on record for the time of year. (Fig. 1). High intensity rainfall events triggered significant surface flooding and transport disruption; they also had damaging ecological impacts – in the Farne Islands puffin chick mortality was exceptionally high. Seasonally rare aquifer recharge was evident in some responsive wells and boreholes e.g. at Ampney Crucis (in the Cotswolds) where groundwater levels were well above the average for late June. By contrast, in East Anglia, June levels at the Dial Farm borehole were the second lowest in a fifty-year series. Fortunately, most reservoir stocks increased modestly through June – an unusual circumstance – and overall stocks for England & Wales stood marginally above average at month-end.

Northern Britain aside, high pressure remained dominant through the first half of July; soil moisture deficits increased substantially and river flows generally

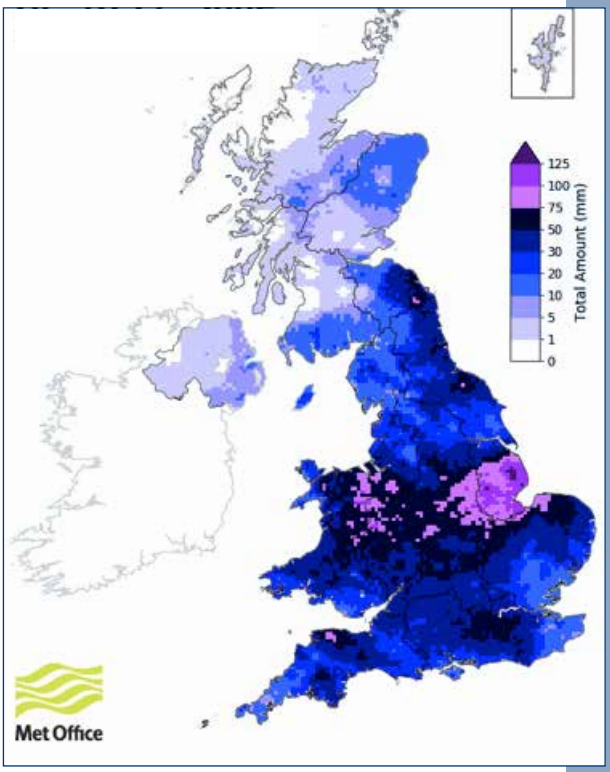


Fig 2 Accumulated rainfall totals (mm) 10-12 June 2019

declined. Flows in some, mostly southern, groundwater-fed streams fell well below average –- primarily a legacy of limited rainfall over the winter and spring of 2018/19. This, together with a surge in irrigation and garden watering led to a Drought Order application by Southern Water to ease pressure on the River Test.

By contrast, a pivotal change in synoptic patterns during the third week heralded another exceptionally wet episode; the frequency and spatial spread of the associated flood warnings was very unusual for mid-summer. Locally intense downpours on the 19th caused widespread transport disruption (e.g. in London and across the southern Pennines) and outstanding 24-hr rainfall totals included 93 mm in Achnagart (in northern Scotland) on the 22nd, 91 mm in Rochdale (28th) and, in North Yorkshire, a reported 50 mm in an hour (30th). After record-breaking temperatures on the 25th (38.7 °C at Cambridge establishing a new UK maximum), Flood Warnings were again widespread late in the month. In the Peak District, exceptional rainfall over a saturated catchment rapidly filled Toddbrook reservoir and damaged the spillway – with the associated risk of dam failure triggering the evacuation of Whalley Bridge (Derbyshire) on August 1st

Terry Marsh
31/7/19

Events Calendar 2019

Date	*Title*	*Venue*	*Type*
01-04 Sept	Intern. Computing & Control for Water	Exeter Univ.	Conference
12-13 Sept	IMA Intern. Conferenceon Flood Risk	Swansea Univ.	Conference
01 October	Flood Forecasting – Developments in Science and Applications + **BHS AGM**	ICE, London	BHS National
02 October	Managing water within our Built Environment (NGIF visit)	Newcastle	BHS National
6 November	Exploiting the UK's Renewed Weather Radar Network	Reading Univ.	RMetS meeting
2020			
09-10 Sept	BHS NATIONAL HYDROLOGY SYMPOSIUM	Lancaster Univ	BHS National Symposium

Managing Water within our Built Environment: National Green Infrastructure Facility Visit

Wednesday 2nd October 2019

National Green Infrastructure Facility, Newcastle University, Newcastle Helix, NE4 5TG

Several record-breaking hydrological and meteorological extremes have been observed in recent years, such as the UK's official highest temperature in July 2019. All of these extremes put pressure on our built environments. As cities and towns continue to transform rapidly, sustainable and integrated water management is required more than ever before. Green infrastructure and sustainable drainage systems (SuDS) relieve pressures on 'grey' infrastructure, and enhance natural drainage patterns across our urban spaces. This, in turn, can reduce flood risk and offer various multiple benefits.

The National Green Infrastructure Facility (NGIF) is a living laboratory, a national facility for collaborative research activities demonstrating the value of green infrastructure and SuDS. NGIF allows researchers and partners to develop and test new designs and technologies under a range of scales, and how they perform over time using advanced sensing networks. NGIF is also linked with the national network of Urban Observatories as part of UKCRIC (UK Collaboratorium for Research on Infrastructure and Cities).

This forthcoming BHS national meeting provides delegates with the opportunity to visit NGIF's indoor and outdoor laboratory, hear about individual projects from across the region, take part in various demonstration activities, and network with relevant stakeholders. Registration opens in August and is limited to 30 places.

Who should attend?

Anyone with an interest in integrated flood management, green infrastructure, sustainable drainage, soil-plant-atmosphere interactions, urban nature-based solutions, stakeholder involvement, and digital sensing networks. Talks, tours and demonstrations will be applicable to a wide audience.

Meeting organisers:

Michael Cranston, Honorary Secretary, British Hydrological Society (michael.cranston@rabconsultants.co.uk)
Eleanor Starkey and Claire Walsh, National Green Infrastructure Facility (green.infrastructure@ncl.ac.uk)

Follow updates on Twitter: @britishhydrosoc and @NGIF_UK



Photo: Amy Woodget