Circulation

No. 113
May 2012

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Photo: Jamie Hannaford

This photo of dried-up watercress beds sets the scene for much of this issue.

* photo taken in mid- April, Ewelme, Oxfordshire

Hydrology for a changing world

Dundee
9-11 July 2012

See you there!

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Travel grants

Travel grant applications should be made to the Hon Treasurer at least two months before the conference or meeting. Use the form at *www. hydrology.org.uk/about_awards.htm* or contact **Nigel Goody**, SEPA, 7, Whitefriars Crescent, Perth PH2 0OPA *(tel 01738 448806, email: nigel.goody@sepa.org.uk).*

Student Award 2012

BHS launched its annual student award in 2002 to promote the study of hydrology and raise awareness of the Society at undergraduate level. Prizes are awarded on the achievement, relevance, originality and presentation of submitted final-year dissertations addressing scientific and applied issues in hydrology, judged by a panel drawn from the BHS Main Committee.

Closing date for applications: 6 July 2012, one entry per department.

Further details on our website.

Impact of climate change on wetlands

A new web-based tool has been launched by CEH* to help wetland managers project the impacts of climate change in the next 50 years. Currently for England and Wales, coverage is to be extended to other countries and regions in the near future.

Users plug-in various details of their wetland, such as geographical location, wetland type, and subject of interest (plants, birds, archaeology etc.). The tool works for rainfall and river wetlands, functionality for groundwater-fed wetlands will follow shortly. The tool uses data from the UK Climate Projections programme and interactive results are presented based on 10 000 realisations of future climate. The outputs show whether there is likely to be large, medium, or negligible impact on the wetland.

http://www.ceh.ac.uk/sci_programmes/Water/Wetlands/ClimateChangeAssessmentToolforWetlands.html

*Developed by the Centre for Ecology & Hydrology and its partners, the Open University, British Geological Survey, University College London and University of Exeter, with sponsorship from the Wetland Vision partnership (led by Environment Agency, with Natural England, English Heritage, Wildlife Trusts, RSPB, Wildfowl and Wetlands Trust).

President's piece

The rain is hammering down as I write, but this very much the Drought issue of *Circulation*, as it will take many weeks of the current wet weather to get water supplies back to a more comfortable position. Even if the water shortages do not unfold as predicted, the dry weather of the last two years has exposed a vulnerability in the country's water use planning and we would be wise to use this warning to improve matters — increased variability seems to be the one climate certainty.

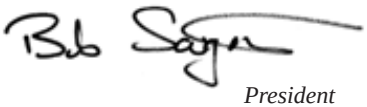
One of my illustrious forebears — Allan Lambert — has provided an article about leakage, which should give you enough ammunition to hold your own in any discussion on this subject (*though what about the urban tress, Alan — they depend on it!*) and Chris Green's piece is about squeezing more water out of existing systems by optimization. The way this is achieved, by 'natural selection' within a genetic algorithm, seems very apt if we are to adapt our systems to a changing climate and one wonders what solutions would emerge from looking at the whole country's infrastructure in this way.

And there is some useful discussion on the hydrology of droughts — though I suspect there will be a lot more once we have some more data from the current one — unless it has already ended, of course.

The drought has also been discussed on the BHS LinkedIn group (http://www.linkedin.com/groups?about=&gid=3897808 if you haven't yet joined) and some interesting strands have come from contributions there. Some that jumped out for me were:

- The public water supply is a relatively minor part of water use — and one that is not actually consumptive as the water is generally returned to the environment, albeit in a different location. Agricultural usage is far greater and often results in no return.
- The debate between supplying to meet demand and managing demand to match supply is still continuing, but the idea of matching regional development to water supply has yet to be considered.
- There is as yet little appreciation of the role water harvesting and re-use can play in supplying water to communities. The December Water White Paper makes no mention of either, despite being focused on sustainable water supplies.
- There is no focus for national planning — water companies are tasked with producing their 25 year plans and the Environment Agency provides a strategic overview but all the other factors, inter-regional transfers, agricultural usage, regional development, are not considered. Matching water usage to the country's hydrology seems a long way off.

BHS is also co-sponsoring a meeting with ICE in the autumn on "*Drought: impact and solutions*" (on 8th October – save the day) where many of these issues will be discussed. Hydrologists have much to contribute to the debate. It certainly makes a change from floods — though we might be having some of those too!



President

Directory of UK Water Researchers

A new directory of those active in water research in the UK has been launched at

www.ukwaterresearch.net

The UKWaterResearch Directory is a comprehensive searchable listing of individuals active in water research.
Designed to facillitate knowledge exchange and networking between UK research providers and research users, it provides summaries of expertise and full contact details that allow you to make contact in one click.

Check your entry now!

Some things Hydrologists need to know about Water Utility Leakage in the UK

Allan Lambert, BHS President 1989–91, offers this brief overview, with some hydrological comparisons, in the hope that it will prevent BHS colleagues from inadvertently perpetuating some of the misunderstandings and fallacies regarding leakage that appear in the media in times of UK drought. He would be happy to provide references and further information on request (allanlambert@wlranda.com)

How is leakage for a Utility calculated?
In England and Wales, annual leakage is usually calculated by a combination of two methods, neither of which can ever be considered absolutely accurate:

- Annual Water Balance: consumption and apparent losses (theft of water, customer meter errors) are deducted from distribution input, to calculate annual leakage
- From night flows in individual districts: when consumption is at its lowest

Utility calculations of leakage are independently audited. England and Wales Water Companies are required to calculate Economic Leakage Levels, which are used to set the targets against which OFWAT compares their performance.

Leakage can also be assessed from first principles, using a Component Analysis technique called Background & Bursts Estimates, developed in the UK 18 years ago. This has similarities to estimates of evapo-transpiration using the Penman formula, based on diverse combinations of key parameters influencing components of annual leakage. Component Analysis is mainly used for analysis, strategy and targeting calculations.

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Office of Water Services (OFWAT) Leakage Figures
When OFWAT figures for leakage are quoted in the media, few of those who publish or read this figure realise that this is 'Total Leakage', which includes leakage on the private underground pipes of customers after the property line. The split between Company and private leakage in 2010-11 was:

- Utility transmission & distribution system (to property line): 2.56 billion litres/day
- On private underground supply pipes (after property line): 0.80 billion litres/day
- 'Total' leakage as defined by OFWAT : 3.36 billion litres/day
- 'Distribution Input' was 14.77 billion litres/day

Unfortunately the media prefer to promote the myth that all leakage occurs on Utility infrastructure, so that is what most of the public incorrectly believe. '*Almost one quarter of leakage occurs on private supply pipes, according to OFWAT figures.....*' is not a headline to sell papers or fit the populist narrative of using the Water Companies as a scapegoat..

But isn't 17.3% for Company Leakage and 5.4% for Private Leakage too high?
Unfortunately, %s by volume are almost useless for assessing or comparing performance because they depend so much on differences and changes in consumption, and on connection density, meter location and pressure. Just imagine if evapo-transpiration losses in river basins were shown as a % of rainfall; Wales and Scotland would be seen as heroes with low %s, the South-East regions as villains with high %s. But would that be a valid comparison taking fundamental differences in key factors into account?

Percentages can also be very easily manipulated by including water exported to other Utilities as part of consumption. OFWAT recognised this in 1995 and stopped publishing %s, as did technical or professional standards groups in other countries (for example Austria, Australia, Germany, Malta, New Zealand, USA). The IWA Water Loss Specialist Group definitely do not recommend using %s by volume to measure or compare performance, or

set targets, as %s mislead more often than they informs.

Why don't Water Companies just replace all of their mains?
Despite media preconceptions, bursts and leakage on mains (if repaired quickly) usually account for less than 20% of Total Leakage. Component analysis consistently shows that most leakage occurs from longer running moderate leaks on service connections, and undetectable small 'background' leaks.

How should a Company's progress in Leakage Reduction be measured?
For measuring progress in reduction of leakage and specifying targets within an individual Utility, the most appropriate Performance indicator depends on the density of connections (per km of mains). IWA Water Loss Specialist Group recommends:

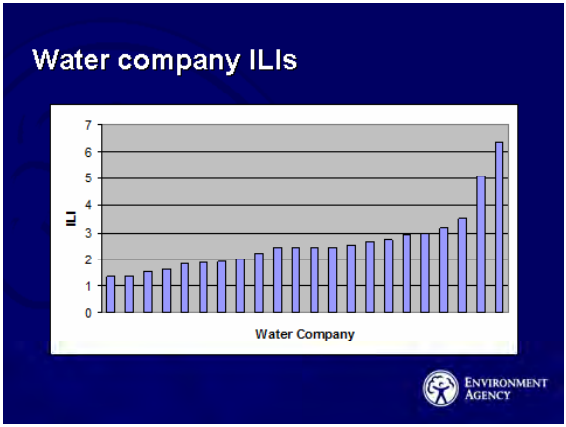
- use litres/service connection/day if more than 20 service connections/km of mains
- use m^3/km of mains/day if 20 or less service connections per km of mains

In the UK, where connection densities of Utilities are generally in the range 40 to 100 per km, litres/billed property/day is a reasonable substitute for litres/connection/day; but m^3/km mains/day should only be used for systems with low (<20/km) connection densities. Most England & Wales Companies had reduced their leakage to economic levels by the year 2000, and leakage has been relatively stable year on year since then.

How can Companies' technical leakage management performance be compared?
The 1st IWA Water Loss Task Force showed, in 1999, that none of the traditional performance indicators (%s, litres/property/day, litres/connection/day, m^3/km mains/day) were suitable for this purpose, as they did not allow for system-specific key parameters (connection density, pressure, meter location). An Infrastructure Leakage Index (ILI) methodology was developed which took these parameters into account for individual systems, this has since been increasingly implemented internationally, with ILIs calculated for many hundreds — even thousands — of systems.

Using the key parameters for each system, an Unavoidable (Technical Minimum) leakage volume is calculated, and the ILI is the ratio of current annual leakage to Unavoidable Annual Leakage. An ILI close to 1.0 is just about as good as you can get (at the current pressure). In 2005 the World Bank Institute developed an international banding system for Real Losses management performance based on the ILI.

So how do the England/Wales Company ILIs compare with other countries?
Difficult to say, as the only publicly available calculation were done 10 years ago by David Howarth of Environment Agency using 2002/03 data, with Companies shown anonymously (see below). Attempts are being made by IWA Water Loss Specialist Group UK members to obtain data to calculate ILIs for UK Utilities for 2011–12. Comparisons can then be made with ILI data sets from Australia, Europe, South Africa and North America.



How important is pressure management in leakage management
Pressure management has been recognised in the UK for over 30 years as a key driver for managing leak flow rates, with thousands of pressure management schemes implemented over that period. International research

over the last seven years has also shown that pressure influences frequency of bursts and leaks, economic frequency of active leakage control, infrastructure life, and some components of consumption. On average, leak flow rates vary linearly with pressure, while background (undetectable) small leaks are even more sensitive to pressure. Some British companies are world leaders in equipment for advanced pressure control.

Almost all aspects of evaporation and evapo-transpiration are strongly influenced by temperature; pressure has a similar all-pervading influence on leakage and demand management. Unfortunately, OFWAT has never required Utilities to calculate and publish their average pressures.

Wouldn't UK leakage management be easier if every property was metered?
Studies in Australia, where all customers are metered at the property line, show that there would still be some errors in leakage estimates, although the errors would be smaller than at present. However, the key issue for reducing leakage volumes relates to where the customer meters are located. If they are all located at the property line, Australian studies clearly show that leakage on customers pipes would be significantly reduced, as even small leaks are quickly identified each time the meter is read.

However, to date, UK practice, driven by OFWAT, has largely allowed meters to be located inside properties, so that customers can read their meters more easily.

Rota cuts were used during the 1975/76 drought – are they effective?
If you had to reduce compensation water from a reservoir, would you even consider shutting it off completely at times, then running at full rate at other times? The consequences for the river ecology would be disastrous.

Similarly, the consequences of rota cuts or intermittent supply on distribution systems is highly adverse, due to the increased numbers of leaks and breaks when the mains were recharged; there is also the possibility of contamination. A recent well documented study from Cyprus showed that more water was lost during and after the rota cuts than during continuous supply. It is definitely preferable to operate the system continuously at lower pressure (which is what has been previously done in Brazil to avoid intermittent supply).

Allan worked in the UK in hydrology and water resources from 1962 until the early 1990's. He then became interested in leakage management and has been working in this field in the UK and internationally in more than 20 countries since then. He was Technical Secretary to the 1992-94 England & Wales Water Loss Initiative, Specialist Adviser to the 1995-96 House of Commons Environment Committee, leader of the first Water Loss Task Force (now the Water Loss Specialist Group) of the International Water Association (IWA), and is the author of numerous papers, and books such as the Financial Times Energy Report 'Managing Water Losses – Economic and Technical Issues'.

Editorial

A new look for spring!

We have been very busy on new designs for our web pages, which should appear shortly, so we thought it was now time also to give Circulation a bit of lift by going for full colour printing. Print technology moves on, just like everything else, so it is no longer an extravagance to let the excellent photos provided by contributors to shine out in true glory.

Celia Kirby

Water Security
Knowledge Exchange Programme

— a new long-term inititative launched by NERC. The aim is to engage with users to accelerate uptake of existing research, and to shape water research for the future.

More details at www.wskep.net

UK Hydrological Bulletin: February – April 2012

The synoptic patterns that resulted in exceptional rainfall deficiencies across much of western Europe were maintained through the late winter and early spring. Correspondingly, the UK drought intensified and extended its spatial extent but is still focused on the English Lowlands where the margin between rainfall and evaporation losses is narrow and concentrations of population, intensive agriculture and commercial activity create high water demand. An exceptionally wet April moderated agricultural drought stress but had only a limited impact on seasonally very depressed groundwater resources.

After a wet start, storm frequency declined markedly through the winter as persistent high pressure diverted most Atlantic frontal systems to the north of the country. Although snowfall extended down to the South East on the 4th February, the month as a whole was mild and dry with long sequences of days when precipitation was restricted to fog-drip. Winter (Dec-Feb) rainfall totals were below 70% of average across parts of eastern and southern Britain and through the UK's driest March since 1953 rainfall deficiencies in the drought-affected regions reached an exceptional magnitude. The 2011/12 winter was the sixth successive season to register below average rainfall in parts of central England and, crucially from a water resources perspective, England registered its 2nd lowest rainfall for successive winter half-years (Oct–Mar) in a series from 1910 (see Figure 1). Rainfall deficiencies can be traced back to the winter of 2009/10 and, whilst several similar or drier 'two–year' droughts have occurred (e.g. 1995–7, 1990–2, 1932–34, 1920–22), the hydrological severity of the current drought strongly reflects the disproportionate concentration of the current rainfall deficiency in the autumn-to-spring timeframe.

Runoff rates which were seasonally depressed through the late autumn of 2011 across much of southern Britain, increased during December but the seasonal recovery stalled, and sustained recessions characterised many rivers through the early months of 2012. Rivers registering new late-March minimum flows showed a very wide distribution (from the Scottish Dee to the Medway in Kent, and the Camowen in Northern Ireland). A few rivers including (e.g. the Tone in Somerset and the Dorset Stour) reported March runoff totals lower than those recorded during the extreme drought of 1976. The drought's severity in the worst-affected regions is best captured by medium-term runoff accumulations: for the winter half-year (Oct-Mar), runoff from the English Lowlands is the 2nd lowest (after 1976) in a series from 1961 and unprecedented in the April-March timeframe. Across much of the country March river flow patterns were more typical of the late summer and imply a contraction in the stream network comparable to any experienced in the last 50 years (for the early spring). The continuing failure of springs, the loss (albeit temporary) of aquatic habitat, low oxygen levels, limited effluent dilution, wetland dessication, and the appearance of algal blooms have underlined the environmental and ecological stress that is a defining characteristic of the current drought.

The regional focus of the drought

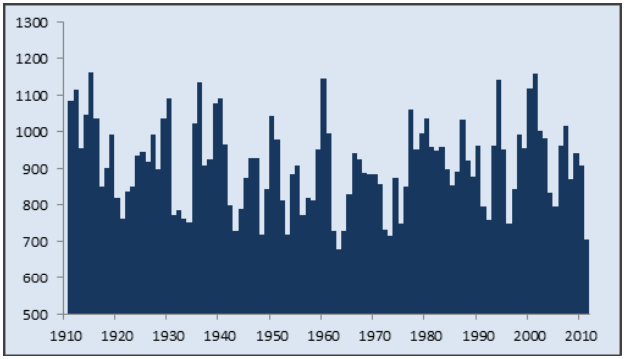


Fig 1 *Two-year winter half-year rainfall totals for England Data source: Met Office, National Climate Information Centre*

in water resources terms is underlined by the early spring reservoir stocks and groundwater levels in the major aquifers. For England & Wales the decline in reservoir stocks through March was the largest since 1993 but, entering April, stocks remained within 10% stocks of the average for the time of year throughout most of northern Britain, Wales and Northern Ireland. By contrast, stocks in some reservoirs in southern and eastern England (including Bewl, Ardingly and Rutland) were at their lowest for early April. The drought's impact is even more compelling in groundwater terms. The meagre flows in baseflow-dominated streams and rivers is a direct reflection of the historically depressed groundwater levels across many major aquifer outcrop areas. Generally the seasonal recovery in groundwater resources through the winter was extremely weak; this is particularly true of the Chalk. Figure 2 shows groundwater levels for the Stonor Park well in the Chilterns; only a modest rise occurred through the 2010/11 recharge season and there is no evidence of a recovery through the winter of 2011/12 − the well was dry by February. Based on a network of Chalk index wells and boreholes with long records, overall storage in the Chalk for March was lower than in 1976 and, in a series from 1951, only 1992 has registered modestly lower overall aquifer storage (see Figure 3).

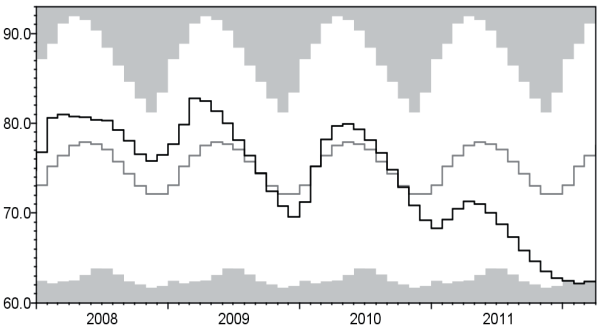


Fig 2 *Groundwater levels in the Chalk at Stonor Park*
Data source: Environment Agency

Throughout the spring latter stages of the drought a mix of measures has been deployed to moderate the drought's impact (e.g. additional water transfers, augmentation of low flows, fish rescues and public appeal to moderate water usage). In early April these were supplemented by hosepipe bans affecting around 20 million consumers in eastern, central and southern England. This closely coincided with a decisive change in synoptic patterns, bringing much cooler and much wetter conditions across the UK. Provisional data indicate that, although spatially very variable, April rainfall totals across much of the drought-affected regions exceeded the April average by 80% or more. Locally intense downpours were common and runoff rates increased smartly in responsive rivers; by the fourth week, flood alerts were widespread – embracing rivers from Cornwall to north-east Scotland.

The April rainfall was particularly beneficial for farmers and growers but with late-March soil moisture deficits the highest on record for the UK, and the onset of the growing season boosting evaporative losses, it had only a moderate impact on the water resources and environmental dimensions of the drought. In the absence of further exceptional late spring and early summer rainfall across the drought-afflicted regions, rivers flows — particularly in permeable catchments — will decline further

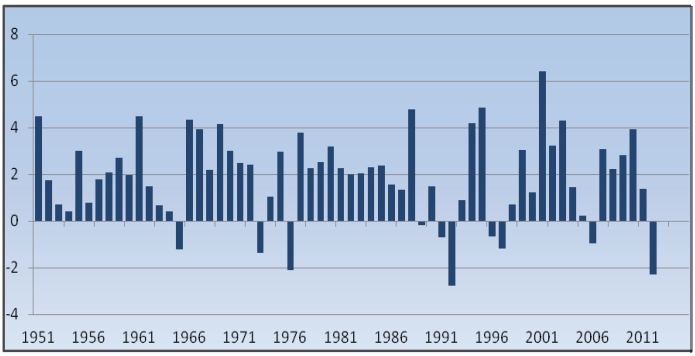


Fig 3 *An index of overall storage in the Chalk for March*

and groundwater level recessions will continue. Natural base levels have been reached or closely approached, remarkably early in the year, at a number of index wells and boreholes. At such sites little further decline in levels is anticipated but the possibility remains that, by the autumn, groundwater resources in some regions will have fallen to levels registered only five or six times in the last 100 years.

Terry Marsh
Centre for Ecology & Hydrology
23/4/12

For more details of the National Hydrological Monitoring Programme please visit:

National Hydrological Monitoring Programme: http://www.ceh.ac.uk/data/nrfa/nhmp/nhmp.html

American Geophysical Union Fall Meeting

San Francisco, California 5–9 December 2011

The opportunity to attend the AGU Fall Meeting last December was fantastic one, made possible by a travel grant from the BHS. On hearing rumours of 20 000 scientists, educators, students and policy makers gathering to divulge and discuss their latest findings in subjects ranging from seismology to astrophysics, I was a little daunted. However, by focusing on hydrology, and largely due to the impressive level of organisation at the conference, my colleague and travel companion from Newcastle University, **Alex Nicholson**, quickly found our feet around and about the rather impressive Moscone Center.

Before I summarise our AGU experience, it is worth mentioning the Berkeley Catchment Symposium, held annually on the Sunday before the AGU meeting. The day was efficiently and enthusiastically convened by **James Kirchner**; **Günter Blöschl** gave an insightful talk on the validity of flood frequency curves and how they should be more dependent upon runoff coefficients and their relationship to catchment chemistry and biology as opposed to statistics alone; and **Tom Bullen** delivered a passionate, eye-opening account of metal stable isotopes and their use in catchment science; clearly a field with massive potential to help us better understand catchment behaviour.

Monday morning marked the start of the AGU conference and it was straight to work. Alex and I teamed up to present a poster on behalf of our wider research group in a session called "The evolution of water management paradigms". Despite being truly gargantuan, the poster hall provided a great forum to meet fellow delegates and discuss our own and other people's work. We offered an example of real-life, proactive, interventionist catchment management where runoff regimes are being actively manipulated in order to lower flood risk and reduce diffuse water pollution from agriculture.

The accompanying oral session took place in the afternoon and commenced with an invited talk by **Uri Shamir** that considered the role of hydrology in water resource management. He highlighted the importance of gathering data and information covering all aspects of hydrology in order to better inform the management domain.

Perhaps the most inspiring moment of the day for me was the presentation of an alternative to standard weighing and tipping-bucket rain gauges; **Ryan Stuart** from Oregon State University demonstrated a new, simple, and low-maintenance rain gauge. Put simply, it measures the change in resonance of a swinging rain accumulation

device (or in this case a bucket with synthetic wool inside mounted to a wooden spring board). Although very simple in construction, the prototype device has been shown to give very accurate rainfall and evaporation volumes and rates when calibrated.

Also, a poster on the NERC Environmental Virtual Observatory (EVO) by **Robert Gurney** showed how the project aimed to exploit cloud computing to make environmental data more accessible and provide tools to analyse that data.

Alex Nicholson presented a poster that introduced a simple model to represent man-made flood storage during storm events. His study tested the man-made features using a combination of modelling techniques and observed data analyses from results from the Belford project. The poster concluded that the various analyses had generated confidence in the viability of the features to impact downstream flooding.

Paul Whitehead began proceedings in an interesting session called "Population 7 billion and growing: food, water and energy security in a changing climate" with a talk which looked at competing demands and water scarcity in the River Thames and its catchment and used the Integrated Catchment (INCA) model to simulate the impacts of climate change on flow regimes and the impact on water quality, particularly nitrate and phosphorus loads. A point raised during questions was that due to natural lag times it could be decades before we see a reduction in nutrient exports in response to mitigation measures, a very important issue to be made clear to decision-makers.

Memorable talks from another session entitled 'Threats on water: chemical and isotope monitoring and integrated modelling of water quality across scale in ecohydrological systems", were given by (1) **Wilfred Wollheim**, who argued that heterogeneity in a river system, in this case beaver dams and other interferences, can increase its capacity to deal with increased nutrient loads by increasing residence times and denitrification; and by (2) **Christian Stamm** who, again, demonstrated the great potential of isotopes: specifically how the signature of oxygen associated with phosphate was proving to be a promising tool for such source tracing in the environment.

The "Landscape system response under change" poster sessions proved very informative: of particular interest to me was a study into landscape, climate and management controls on suspended sediment dynamics by **Stuart Baker**, an investigation into the sediment and carbon storage potential of natural log jams in forested catchment by **Natalie Beckman**. This was significant as we construct woody debris schemes in some of our work to attenuate flood waters but had not really considered their impact on water quality.

My presentation on the use of soft-engineered runoff attenuation features to mitigate diffuse water pollution from agriculture was on the Thursday afternoon in a session entitled "Agricultural surface and groundwater quality". Attendance was perhaps a little 'compromised' by the fact that free beer was being issued in the communal areas at the same time, but a good number of people were present nonetheless.

Ana-Maria Garcia from the USGA was invited to describe work by the USDA and USGA that used the SPARROW (SPAtially Referenced Regression On Watershed attributes) model to assess the effectiveness of conservation practices, mainly erosion control, on water quality. **Russell Adams** presented a study that used TOPMODEL to improve understanding of pathway dynamics that connect source areas of pollutants to watercourses. He showed how farm ponds could act as nutrient sources, as well as sinks, depending on the time of year, a point of relevance and interest to me and my work.

Several other talks discussed nitrate concentrations in groundwater; **Jean Moran** delivered a strong message that very high nitrate concentrations had been detected in aquifers and were threatening wells used to irrigate the Salinas Valley (also known as the 'salad bowl of the world') as well as drinking water wells. I believe my own presentation went well and that it was good to show some on-the-ground mitigation work being carried out in catchments (see photos). The talk raised some interesting questions and discussion points after the session and I went away with many new ideas but also with the belief that our work had relevance to many people the world over. **Sim Reaney** rounded off the day with an interesting talk on hydrological connectivity, thresholds and system responses. More specifically, he discussed the idea of locating areas of dis-connectivity in



Catchment systems engineering involves the identification of overland, fast-flow pathways….

the landscape and how these could be used to help reduce diffuse pollution, particularly sediment losses to water.

Friday was the last day of a very busy, somewhat tiring, but altogether fascinating and enjoyable week. A session called "Water quality in river systems" contained some very absorbing presentations that notably included the development and testing of a bank erosion modelling tool for informing catchment management by **Victoria Janes** and an evaluation of the role of stream restoration in reducing nutrient loading by **Daniel Baker**. Overall, I thoroughly relished the trip to AGU and the chance to visit San Francisco; in my opinion, a fantastic city with lots to do and see. I would highly recommend the AGU Fall Meeting to anyone as a way to disseminate your own work, but just as importantly, to engage with other people and learn about theirs. Finally, a sincere thank you to the BHS for generously providing me with the travel funding that made the trip possible.

Nick Barber
Newcastle University

Copy deadline for Circulation No. 114 25th July 2012



The interception of polluted flow pathways using Runoff Attenuation features (RAFS) helps reduce sediment and nutrient delivery to watercourses

New members

Louise Algeo.....Black & Veatch, Redhill
Abdulkhaliq Aljuhani..... University of Birmingham
Emma Almond.....Winsford, Cheshire
Biniam Biruk Ashagre.....Cranfield University,Bedford
Helen Samantha Dick.....Environment Agency, Solihull
Joanne Cullen.....Environment AgencyWales, Bangor
Jennifer Louise Geary.....University of Aberystwyth
Sophie Denise Greenly-Jones.....Environment Agency Wales, Bangor
Michael Green.....Halcrow Group Ltd, Birmingham
Claire Grout.....Atkins, Epsom, Surrey
Phil Howard.....C E H Wallingford
Elizabeth Lewis.....University of Newcastle
Senthuran Loganathan .....Balfour Beatty, West Malling, Kent
Jennifer Luther Thomas.....Southampton
Robin Saunders.....Innervision Design,Bishop's Stortford
Ben Smith.....King's College London
Fiona Thompson.....University of Stirling
Nathan Weald.....H R Wallingford Ltd

Minewaters 2012: Understanding and addressing environmental impacts in the UK and beyond

Cardiff University
27 January 2012

Cardiff University was the location for the Geological Society's one day 'Minewaters 2012' event. The conference theme was centered on understanding the environmental impacts of coal and metal mining now and in the future. The context of the conference was the environmental legacy of historical mining activities in the UK with its long history of mining and extraction of metalliferrous ores that can be traced back to Roman times. Metal mining activities have largely ceased now, although prospecting has started at a few sites in response to the recent surge in global metal prices.

The Environment Agency estimate that over 3000 abandoned metals mines exist in England and Wales, and that drainage from these mines is causing approximately 8% of river water bodies in the UK (17% in Western Wales RBD) to be considered 'at risk' of failing to meet EU Water Framework Directive requirements in 2015. Many coal mines have ceased operation too, and, although we largely understand the challenges of treating coal mine drainage, there is a need to continue to monitor and to be innovative in our solutions. The longevity of mine drainage means that meeting the water quality and ecological requirements of the WFD in mining-impacted catchments presents an immense challenge for scientists and regulators.

Several key questions exist: What are the environmental impacts now? How are these impacts likely to change in the future? How do we measure these impacts? How do we remediate coal and metal mine drainages? How do we assess the success of remediation schemes?

The conference was opened by **Chris Mills**, the Director of Environment Agency Wales, who set the context for the conference and highlighted the severe environmental impact of this historical and, often forgotten, industry. Mr. Mills emphasised the 'significant barrier' presented by coal and metal mine drainages to meeting the objectives of the Water Framework Directive. He talked about how many of the 'at risk' water bodies are located within Special Areas of Conservation, National Parks or Areas of Outstanding Beauty. The Environment Agency is currently seeking funds to remediate the highest priority metal mine sites in Wales.

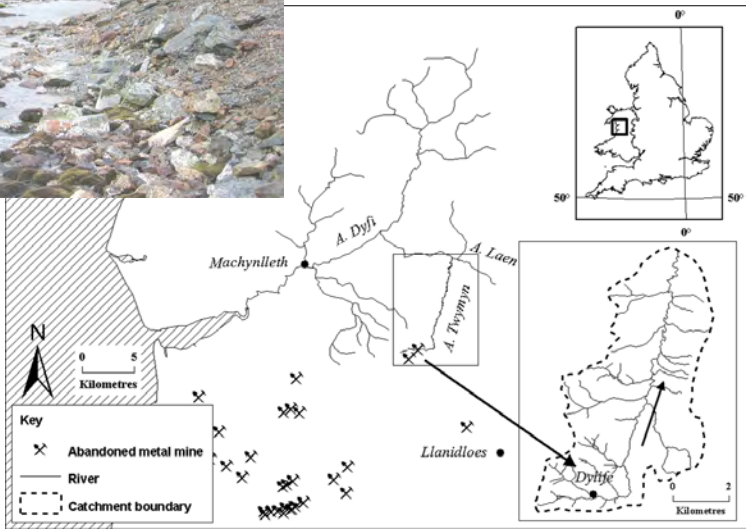
The scientific programme was opened by **Dave Johnston** and **Hugh Potter** of the Environment Agency. Their talk presented a synopsis of what is currently known about the environmental impacts of coal and metal mine drainage in England and Wales and how this information has been collated and analysed to identify priority sites for remediation. Funding from the Welsh government and national government has allowed detailed investigations of priority sites to inform future remediation schemes.

Patrick Byrne (Lancaster University) presented the results of a study which investigated the ecological impacts of historical metal mining in the River Twymyn, central Wales (see opposite). Benthic macroinvertebrates are widely used as bioindicators of contamination in river systems. This study compared the effectiveness of a range of traditional biological indices, used widely by scientists and regulators, and more advanced multi-variate statistical analyses which combine environmental and biological data in a single analysis.

Using biological indices, the ecological community appeared to be



River Twymyn as it flows past mine spoil at Dylife mine, central Wales.



Central Wales mining district with location of study area and Dylife mine.

in a relatively stable state, despite gross contamination of the river water and sediments. However, Canonical Correspondence Analysis revealed a significant environmental (metal) gradient in the river system which is influencing the structure of the macroinvertebrate community.

John Gunn (University of Birmingham) presented a study which examined some of the environmental impacts of lead mine drainage on the River Lathkill, Derbyshire. Immense networks of drainage levels, or soughs, were constructed under the Peak District from the 17th century onwards to allow deeper mining. Using water tracing experiments, this study investigated how extensive collapse of soughs in the region has led to capture of water from the River Lathkill. This has caused ecological stress in the river due to loss of flow but also as a result of recharge by water that had flowed through the soughs and accumulated high metal concentrations.

The complexities of estimating mine water treatment facility design criteria from limited data were discussed by **Peter Thorn** (Atkins Ltd.) using a case study from Nova Scotia, Canada. This study combined a hydraulic model with a PHREEQC geochemical model to predict potential changes in mine water chemistry, mineral precipitation and resultant blockages to underground flow paths. Such predictive modelling tools help to incorporate enough flexibility in the final design scheme to ensure expensive redesign is not required at a later date.

Adam Jarvis (Newcastle University) discussed some of the issues surrounding passive remediation of metal mine discharges in the UK. Pilot-scale units have been shown to perform well for point source discharges; however, major challenges need to be met before effective full-scale systems are a reality. A particular challenge relates to the long-term performance of systems in the face of variable environmental and hydrological conditions. It is known that diffuse mine drainage discharges increase in importance as discharge in a catchment increases, and this can negate the treatment of point source discharges.

Devin Sapsford (Cardiff University) talked about the difficulties of treating mine drainages in areas of restricted land availability. Many mine water treatment schemes require large land surface areas to increase residence times of metal contaminants with attenuation/ transformation media. This presentation examined how

iron removal mechanisms and system hydraulics can be optimised and designed better to develop passive treatment systems with minimal footprint.

Ian Watson (The Coal Authority) described the engineering and development of a mine water treatment scheme to prevent rising mine water in County Durham from contaminating the East Durham Aquifer, the River Wear and the coastal areas of East Durham. Long-term protection of the nearby water resources was achieved by a large scheme incorporating pumping of mine water, and both active and passive treatment solutions.

Prediction and performance of water management strategies for mining facilities requires an understanding of the mechanisms of water infiltration and geochemical reactions. **Andrew Barnes** (SRK Consulting UK Ltd.) demonstrated how the integration of laboratory and field data with geological data may be scaled, using numerical predictive calculations, to assess source generation of mine waters, contaminant percolation and transport, and geochemical reactions.

I would like to express my sincere gratitude to the British Hydrological Society for supporting my attendance at this conference and for enabling me to present my research.

Patrick Byrne
Centre for Sustainable Water Management,
Lancaster University

Climate Impacts on low flows and droughts

International Symposium, Vienna, Austria 1–2 March 2012

This two-day symposium was organised and hosted by the Institute of Applied Statistics and Computing at BOKU University, situated a short distance north west of Vienna city centre. The purpose of the meeting was to bring together drought experts from a variety of disciplines to compare the current status of drought research and implications for water resource management. The primary focus was on the European continent, providing a platform to discuss large-scale studies in a regional context and also national/regional studies in the European context.

Despite EGU being just around the corner, the meeting was well attended, with representatives from across Europe and beyond; the 21 oral presentations and 26 posters displayed addressed the six conference topics:

1 Drought processes in the atmosphere and in catchments
2 Trends and patterns of droughts
3 Reconstruction of historic droughts
4 Modelling low flows and droughts
5 Drought scenarios
6 Implications for water resources management

Day one began with a warm welcome and introduction by Prof. **Gregor Laaha** (BOKU) who highlighted just how timely such a meeting was, when he spoke of the current drought situation in the UK. Oral presentations were given throughout the day, covering topics one to four, broken up by pastry-filled coffee breaks and poster sessions. A discussion session was held by the keynote speakers of the day — **Lena Tallaksen** (Oslo), **Sonia Seneviratne** (ETH Zurich) and **Neil Macdonald** (Liverpool) — and was a valuable opportunity for open discussion and a review of the day's presentations.

Three key themes for discussion were picked out. Firstly, data availability — the importance of filling the 'white spots' (regions' missing data) was emphasised in order to develop research that is truly at the continental scale. This led nicely onto a discussion of data quality: although as researchers we want access to as much data as possible, we must bear in mind that data providers necessarily need to restrict access to quality control and provide us with the 'health warnings'

(to quote Jamie Hannaford, CEH) that we need in order to deliver robust science. The session ended with drought modelling, with an emphasis on ensemble forcing and prediction.

After a long, but highly informative day, we conference delegates were re-invigorated by the proposed social event and dinner. After a bit of bus hopping and an un-scheduled stop in a nearby village, we were treated to an evening of wine tasting and authentic Viennese food (served with more home-grown wine!). It seemed us that drought researchers enjoy a variety of reds and whites, but are not partial to a rosé — the only wine to make it into the spittoon (or bucket as is commonly known).

Day two was dedicated to covering the final two topics (five and six) and featured another lively discussion hosted by the keynotes (**Gregor Laaha** (BOKU), **Bodo Ahrens** (Frankfurt) and **Christian Kopeining** (Austrian Govt.)). This began with: Which drought indices should we be using? Many insights and opinions were given, with no clear winner. An obvious conclusion, but I think an important one, since we must remember that drought indices are necessarily selectively based on the individual regions and types of drought being studied.

The second and final discussion theme centred on approaches to communicating science with stakeholders: top-down compared to bottom-up approaches. The practitioner advocated the use of simple language, brief summaries, and a clear message — tell us what is relevant. As scientists, can we or should we achieve this? Do we need a 'middle man' to translate science to the stakeholder? This debate was concluded nicely by a comment reminding us that the IPCC offers guidance on how to communicate science: to what degree are we taking advantage of this?

Once again I would like to offer thanks to BHS for providing the funds to enable me to attend this highly topical symposium. The meeting was hugely informative due to the broad range of topics covered and was an excellent opportunity to mix with overseas drought researchers. Credit should also be given to the organisers of the symposium. I think we (delegates) would all agree that this was a smoothly run, interesting and topical meeting!

A full list of speakers and talks can be found at: http://statistik.boku.ac.at/cilfad2012/

Beverley Todd
University of Liverpool

A letter to the Editor....

Since the beginning of this week, with the news media were swamped by various stories on the extension of areas with declared drought conditions, I have been searching on the CEH website for the Hydrological Summary for March. It is not yet available. This situation allows newspaper, TV and radio "environmental correspondents" a field day to put out stories which cannot be checked against facts. With today's fixation with providing the public with information, and the capacity of computing and the internet for dissemination, it seems a contrary situation that it takes more than half a month to put out a formatted report.

As a lowly Assistant Hydrologist with a River Authority, one of my tasks was to produce the monthly hydrological summary and water situation report within 7 days of the end of the month. I don't think I missed my deadline, and in those days, the "computer room" was off-limits to mere scientists, so I had to rely on other people to produce the data that I had to process and collate.

Still, that's progress for you.

James Dent
Independent Consultant
17 April 2012

and a reply....

In response to James Dent's letter in Circulation regarding the, seemingly tardy, publication of the UK Hydrological Summary for March, perhaps I could provide some essential background.

The high level of media interest in the drought during early April was stimulated by the introduction of hosepipe bans and the subsequent extension of the area officially designated as in drought. The CEH Press Office, supported by members of the National Hydrological Monitoring Programme (NHMP) team, has been exceptionally busy dealing with drought enquiries and data destined for the March Hydrological Summary provided the basis for many media interviews and a raft of briefing material. I would not pretend that this effort was necessarily reflected in the media headlines.

I share James's nostalgia for the River Authority era and readily salute the committed hydrological monitoring activities maintained by a number of notable individuals. But monitoring and data stewardship capabilities varied greatly across the 27 RAs and the creation of the Water Authorities didn't herald any rapid harmonisation. This, in my view, contributed to the inadequate contemporary monitoring of the development and intensification of the 1975/76 drought.

The Hydrological Summaries endeavour to provide an authoritative synthesis of hydrological conditions and water resources status across the whole of the UK. They rely on the provision of data from a wide variety of sources – from national, regional and local organisations in both the public and private sector. Telemetry allows a proportion of the required data (e.g. river flows) to be at the beginning of the subsequent month but some, mostly non-automated, data streams are necessarily slower (e.g. manually dipped wells, some reservoir stocks and derived datasets including areal assessments of soil moisture deficits).

The reputation of the NHMP depends in large part in ensuring as little erroneous material as possible appears in the published Summaries. Correspondingly, considerable effort is devoted to data validation and verification. This was particularly true for March – a remarkable month when existing monthly hydrometric records were eclipsed in many areas, and drought conditions intensified. I can say with confidence than in the 24 years since the Hydrological Summaries were first produced, no single month has required greater analytical input than March 2012.

With the Easter break falling in early April, it is unsurprising that the release of the Hydrological Summary (on the 17th) required the full span of our 10-working days publication deadline. Reducing the publication lag of the HS is a continuing aim but it needs to be achieved without compromising the scope or integrity of the featured material.

Members of the NHMP team are always available to discuss current hydrological conditions, and enquiries are welcome (please submit emails to: nhmp@ceh.ac.uk).

Terry Marsh
Centre for Ecology & Hydrology
24 April 2012

Peter Wolf
Early career hydrologists' event

University of Birmingham
3–4 April 2012

The BHS Peter Wolf Early Career Hydrologists' Event was held this year for the first tim at the University of Birmingham. The majority of the attendees were postgraduate researchers from across the UK, although several delegates joined us from consultancy positions and one post-doc travelled all the way from Switzerland. The aim of the event was to provide an open and friendly atmosphere for hydrologists in the early stages of their career from both academia and industry to present their work. Although for many delegates this was their first experience of a conference, it was pleasing to note that the overall quality of presentations and posters was extremely high.

The keynote presentation was given by **Geoff Petts** (University of Westminster) who delivered an informative, wide-ranging, and at times provocative talk on the global challenges facing hydrologists in the next century. The need to minimise alternations to river flow regimes was emphasised in order to sustain healthy freshwater ecosystems and their societal benefits in the face of an ever-growing human population.

The presentations from delegates that followed covered a broad spectrum of topics. Several talks focused on detecting and understanding trends in historical records to detect climatic drivers of hydrological change. Others looked forward to assess the potential hydrological impacts of climate change in the UK and the implications for policy and management. The diverse range of study areas associated with hydrology was evident as the event progressed, with further presentations covering topics from sediment dynamics to glacial retreat, and macrophyte growth to contaminant transport.

In an invited talk, **Nigel Goody** (SEPA and BHS) provided delegates with a whistle-stop tour of his career in hydrology (36 years and counting!) and also delivered some sound advice on the benefits of being a hydrologist for delegates considering a similar profession. He noted that while hydrology has traditionally been the preserve of engineers, recent developments in the field now make it a viable career option for geographers, meteorologists and even social scientists.

In addition to traditional oral presentations, this year's event saw the introduction of micro-presentations in an attempt to provide an opportunity for delegates in the very early stages of their research to present project designs or preliminary results. While only 5–10 minutes in length, these presentations contained some excellent ideas and plans for future work. Hopefully these will come to fruition in time to present the results in full at next year's event!

The two days finished with the award of prizes for outstanding contributions. Following careful deliberation by Nigel Goody and the organisers, prizes were given to **Selma Guerreiro** (Newcastle University) for best presentation, **Andrew Chiverto**n (CEH) for best micro-presentation, and **Marina Dudley-Southern** (Lancaster University) for best poster.

The organisers would like to take this opportunity to thank BHS and the University of Birmingham's Graduate School for their support and financial contributions to the event which reduced the delegate fees substantially. Thanks also go to all the delegates who made the two days such a success.

Phillip Blaen
University of Birmingham

n.b. all of the presentations and a film of the keynote talk are available on the BHS website - see side-bar on the Meetings page

Revision of British Standards for meteorological precipitation measurement



Field evaluation of raingauges at Eskdalemuir (Photo: Karin Grust, SEPA)

The availability of coherent, high quality, precipitation data underpins many areas of hydrology. Across the UK, the Environment Agency, Met Office, SEPA, Ministry of Defence, local authorities, environmental consultants, instrument suppliers, construction companies, further and higher education, public and privately funded scientific research bodies all operate raingauge monitoring sites. To promote consistency across the networks and foster a full and accurate picture of rainfall across the UK, the monitoring of rainfall is described in British Standard 7843.

The British Standards Committee on Hydrometry (CPI/113) decided in 2009 that there was an urgent need to update the existing standard on Precipitation Measurement. The main driver was the fact that the current standard had not been reviewed and updated for nearly twenty years and it was felt that it no longer reflected current practice or technology. Also, it was acknowledged that there was a need to rationalise the current structure of the standard, which consisted of seven individual parts.

A broad panel of hydrometric, hydrological and meteorological expertise was formed to complete this revision. Led by the Environment Agency, the panel included representatives of the Met Office, Centre for Ecology & Hydrology, SEPA and several hydrological consultants (Hydro-Logic, WSP).

Following eighteen months of development and public consultation, the fully revised standard has now been published. **BS 7843**: **Acquisition and management of meteorological precipitation data from a gauge network** comprises four parts:

- BS 7843-1:2012 Guide for design, development and review of a raingauge network.
- BS 7843-2:2012 Code of practice for operating raingauges and managing precipitation data.
- BS 7843-3:2012 Code of practice for the design and manufacture of storage and automatic collecting raingauges.
- BS 7843-4:2012 Guide for the estimation of areal rainfall.

The revised standards will allow ongoing consistency and confidence in the rainfall data produced across the UK by an increasingly diverse set of monitoring technologies and practices. They will give suppliers the opportunity to provide equipment using alternative technology to that described in the previous standard. In turn, this will provide raingauge network operators with a wider choice of instrumentation and provide opportunities to reduce running costs.

The new standards are available using the following hyperlinks from BSi:*

BS 7843-1:2012 Guide for design, development and review of a raingauge network.
BS 7843-2:2012 Code of practice for operating raingauges and managing precipitation data.
BS 7843-3:2012 Code of practice for the design and manufacture of storage and automatic collecting raingauges.

Dave Stewart
Environment Agency
and
Harry Dixon
Centre for Ecology & Hydrology

* or from *:*
http://shop.bsigroup.com/SearchResults/?q=7843
for those not reading this on-line

Operating water resource systems efficiently

As this article is being written (early 2012), there is much discussion in the media concerning the drought-affected areas of the country and those areas which are on the brink of a drought. There are calls to minimise water use, reduce leakage and restrict use. This has again triggered talk in the press for a national water grid. However, the huge costs involved in building, maintaining and occasionally operating such a grid must be considered, and there are also large costs involved in developing and operating any new resources. In addition, there would be environmental costs which will include increased CO_2 emissions as well as detrimental local effects such as reduced river flows and depleted aquifers.

The obvious question to ask before considering any new sources or network connections is "are we operating our existing water resource systems efficiently?" Most of these systems in the more populated parts of the UK are conjunctive use, with multiple sources supplying many different demand centres. Sources are different in nature and so respond differently during drought conditions. So how best to operate these varied sources, such that most of the time most use is made of the cheaper and less environmentally problematic sources while also ensuring they are not over-used in the lead-up to a drought?

We need operating strategies that maximise the Deployable Output (DO) of water resource systems by considering the system as a whole. It may well turn out that some form of national water grid will be required eventually but first we should use the resources we have already as efficiently as possible.

The North Eryri-Ynys Môn system

Keen to do just this and make best use of resources currently available, Dŵr Cymru (Welsh Water) commissioned a research study to look at the operation of the five-reservoir North Eryri-Ynys Môn system in Anglesey and North Wales. Like many other systems in the UK, the reservoirs in this water resource zone have multi-band control curves that determine the maximum amount that can be abstracted according to the current state of the reservoir. These curves trigger lower abstraction rates as the reservoir storage becomes less. The reason for this is to protect the resource, on the assumption that any unsatisfied demand can be supplied from elsewhere.

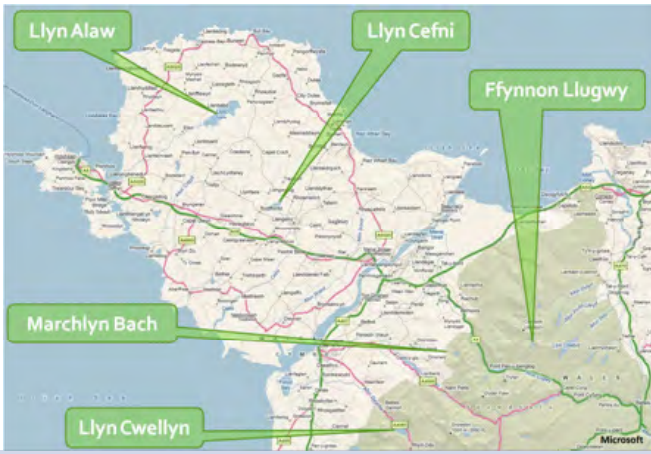
The multi-band control curves currently in use were derived on a reservoir-by-reservoir basis and so they take no account of the state of other sources of supply (i.e. do not consider the entire system).

Consequently, although systems such as this are conjunctive use, the multi-band method of operation is not necessarily the best way to operate the system as a whole. The purpose of this research study was to derive a simple zone-wide operating strategy to maximise the available resources for the system as a whole without adding additional sources of supply.

Building on earlier work with United Utilities and Scottish Water, a powerful optimisation technique was used (Genetic Algorithm, or GA linked to an Aquator model) and a 'whole system' optimisation undertaken to maximise the system's deployable output (DO).

Genetic Algorithms

GAs are probably the best known type of Evolution Programs, which are based on the "design by nature"

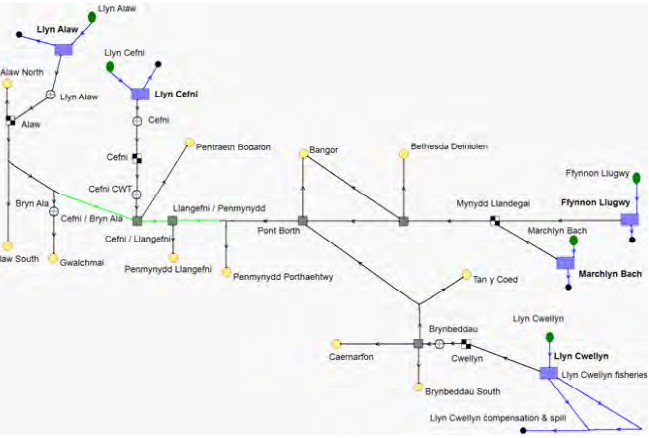


principle insofar as they derive their inspiration from nature by emulating effective optimisation techniques of evolution. They are based on preferential survival and reproduction of the fittest members of a population. In addition, GAs employ the maintenance of a population with diverse members, the inheritance of genetic information from parents and the occasional mutation of genes. These algorithms are best suited to solving combinatorial optimisation problems that cannot be solved practicably using more conventional operational-research methods. Thus, they are often applied to large, complex problems such as those that are non-linear and have multiple local optima.

GAs have many advantages over other optimisation methods. These include the ability to optimise for multiple objectives (in a single model run) such as maximising DO, minimising cost, maximising environmental benefit and minimising CO_2 emissions. GAs are also able to find superior solutions hidden to other optimisation methods.

The model & method

The model's schematic is shown below:



The principle components of the North Eryri-Ynys Môn zone are five reservoirs, five pump stations, four water treatment works, three bi-directional links and eleven demand centres.

This model was connected to the GA optimisation suite at the Centre for Water Systems (CWS), Exeter University, by means of a specially written intermediate application that allowed the model to be controlled as a 'black box' by the optimisation software. Optimisations were undertaken using the maximum length of available historic data (1958–2005).

Results

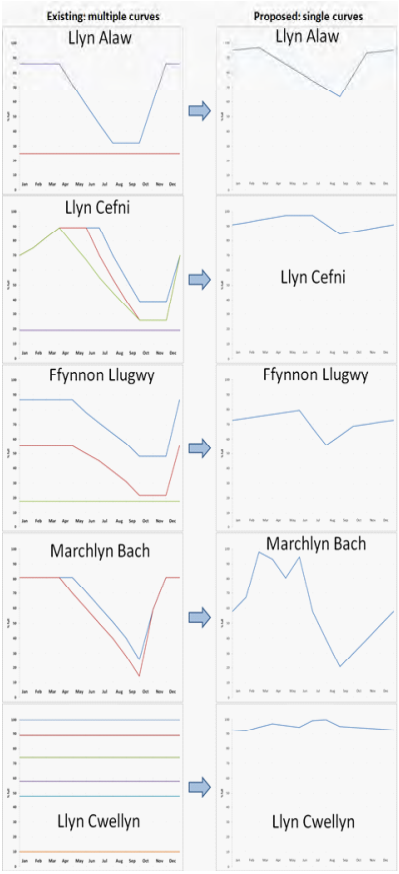
The left-hand set of control curves (shown right) are the existing multi-band operational curves that restrict the amount of water that can be abstracted (as described above). This operating strategy has the additional complication of the band of maximum abstraction varying seasonally on some reservoirs.

In addition to maximising DO, a secondary objective was to obtain 'smooth' control curves. Time constraints prevented the solution being refined further which would be expected to produce smoother curves and possibly a further increase in DO (i.e. to make improvements to both objectives).

The right hand single control curves are those derived by the GA for exactly the same model configuration and reservoir inflows. Thus, the original 15 control curves have been replaced by just five. As well as simplifying operations, the single control curves produced by the GA connected to the Aquator model increased the modelled DO by over 6.5%. These initial results can now be further investigated by Welsh Water using their existing WRAPSim model of the system to confirm whether such a change would be feasible, and as effective, as the modelling indicates.

The GA analysis also produced optimum maximum above and below curve abstraction limits for the five reservoirs. Interestingly, on one of the five reservoirs, Llyn Cefni, the maximum abstraction amount below the curve was slightly higher than that above it. This is an outcome of the holistic optimisation which shows it is better to restrict Llyn Cefni's use when above the curve so that slightly more water can be taken out in times of drought when it is needed to relieve the pressure on other sources. This is counterintuitive and probably would not have been considered before optimisation results were obtained.

The existing multi-curve strategy



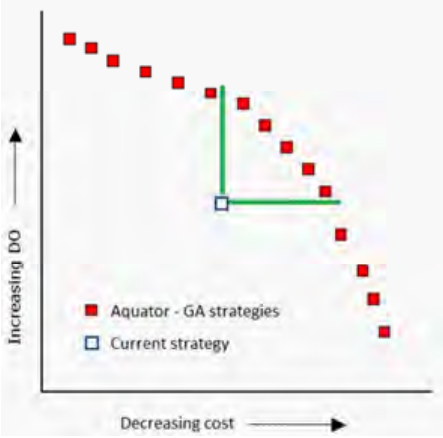
simply provides the maximum that can be taken from each reservoir each day. It does not determine the priority of use should the combined maxima available be greater than the demand that day. The single curve strategy specifies both the maximum and the preferred order of use to meet demand. The order of use is determined based on resource state, where this is calculated as {current storage ÷ control curve storage}. 'Resource state' is therefore greater than 1 when above the control curve and less than 1 when below. The model then uses the source with the highest 'resource state' as much as possible and that with the lowest 'resource state' as little as possible.

Thus a complete operating strategy (including the logic to determine the direction of flow for each of the three bi-directional links) has been derived enabling both the amount to be supplied by each reservoir to be determined and in which direction the bi-directional links should be used each day.

Thus, within the modelling environment, a system operated using the strategy and control curves derived here over the period of the historic record, had the potential to offer greater resilience to drought during those 48 years. Although future droughts will be different in nature, a strategy proven to be superior in the past should provide more confidence if used in the future. However, confirmation is again needed that these gains are reproducible in the WRAPSim model, once it has been set up to operate with the strategy suggested here. Further investigations should also identify whether this change would be operationally feasible.

Optimising to reduce operational cost

No cost information was available during this study although costs of supply normally vary according to which sources are being used. If cost information were available, it is possible, using GA, to add this as an additional objective so that operating cost is minimised at the same time as DO and curve smoothness is maximised. The trade-off curve shown below illustrates the results of such an optimisation where the relationship between DO and cost is clearly visible. (Each point on the curve would have its own value of 'curve smoothness'.) Having produced this trade-off curve, a single point is chosen that represents the preferred balance between operating cost and DO. This point is associated with one set of control curves that becomes the operating strategy.



Conclusions

1. This initial research study suggests a model-wide operating strategy has the potential to increase the DO of a water resource system.
2. In the case of North Eryri-Ynys Môn, the potential increase was over 6.5%.
3. The cost of developing new sources is often quoted as between one and three million pounds per mega

litre. Reviewing operating strategies in this way could reduce the need for or defer developing new sources, save millions of pounds, and might be possible to undertake relatively quickly.

4. In the case of North Eryri-Ynys Môn, the alternative strategy required only one control curve per reservoir, compared to an average of three currently in use, and potentially simplifying operations.
5. Operating costs could also be minimised following this approach if they could be made available.
6. Rather than considering reservoirs in isolation, this holistic approach to design and operating strategies could help minimise the capital and operating costs, improve resilience and minimise the impact on the environment.

Harvey Walsh & Gail Davies (Dŵr Cymru),
Dragan Savic & Mark Morley (University of Exeter),
Brian Cox (Atkins) and Chris Green (Oxford Scientific Software)

Climate change and water resources

There have been several exchanges on this topic since the original article in *Circulation No. 110*, with an interesting dialogue between **Mike Price** and **David Evans**, as reproduced below.

"Groundwater storage is much bigger than reservoir storage."

DE - Yes, but if the aquifer is unconfined you can only use part of its storage, for fear of drying up wells, springs and wetlands.

MP - The point is that even the tiny part you can use is much more than reservoir storage. In 'normal' years (if there are such things any more) the change in water level in the Chalk releases a volume of water of 500–1000 M m^3. In drought periods like 1975–6 and 1988–90, there are roughly double those amounts draining*. Those figures compare with 200 M m^3 for the gross volume of Kielder, our largest storage reservoir, and around 2000 million m^3 for the total reservoir capacity in England and Wales. And the Chalk is a 'low storage' aquifer.

DE - Maybe. But don't try to sell the idea in Norfolk —you wouldn't get out alive! If the aquifer is confined, usable storage may be bigger…

MP - Debatable point in this country — confined S is much lower than specific yield and we don't have large confined aquifers with good quality water in them.

DE …and you probably need artificial recharge, and the practicalities tend to be limiting - so pump enough to make a big hole (to waste if necessary) then ASR? Every time I talk about reservoirs someone asks why not ASR instead. If it were as good as people imagine, wouldn't Thames (and/or Essex & Suffolk, who also have what looks a promising location) have done it by now?

(See below for more on this – Ed.)

"Reservoirs take up good farmland."

DE - Yes, but land is no good if the crops are wilting. A small part of the stored water used for irrigation can more than offset the lost area.

MP - But the crops will only wilt in dry years and will grow in wetter years — the reservoir is taking up the land all the time, whether its water is needed or not.

DE - True, but less and less so as summers dessicate. And we still have to eat in dry years.

MP - I think climate variability is our problem more than long term rainfall reduction.

DE - Both

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* Lewis, M.A., et al., 1993. Groundwater storage in British aquifers: Chalk. *National Rivers Authority, R & D Note 169 (48 pp).*

"Reservoirs suffer evaporation losses."

DE - Yes, but limited. In the example of a reservoir evaporating 10 Ml/d, the original farmland would have evaporated over 7 Ml/d anyway.

MP - But it would have been growing useful food!

"Returning flows from groundwater abstraction are just as valuable athose from river abstraction."

DE - Yes, but the initial impact is different. Groundwater abstractions threaten local water features (as above) and also reduce the lowest river lows. River abstractions with suitable hands-off flows do neither.

MP - But major, reliable river flows are relying on groundwater.

DE - Only some of them

MP - When the baseflow is high, much of the water is running to waste — like leaving the outlet from a reservoir open all the time.

DE - Yes, the vast majority in both cases.

MP - If the baseflow declines the river flow will decline. How do you then do 'hands off' if people need the water?

DE - That's why they need to store it when times are normal. If we had built say Abingdon, Broad Oak and Great Bradley the current drought would be having minimal impact, at least on water supply.

"If climate change reduces recharge, it means lower baseflows from groundwater."

DE - Sadly, yes — but don't forget the highly reliable baseflows from returning water supplies.

MP - If the water is there to supply in the first place.

DE - That's why we need the storage!

"Less recharge means either less baseflow and/or less groundwater abstraction hence all the more need for river/reservoir abstractions."

MP - No — less recharge means less baseflow if there is no abstraction or if you keep abstraction as it is.

DE - I think that's much what I meant - one or the other, or a bit of both. And/or get serious about artificial recharge/ASR. Are you any clearer than I am why nobody seems to have followed up on the Lee Valley ASR scheme, which must be several decades old?

MP - Well, Thames water of course put in Enfield Haringey to store surplus water in the Basal Sands and put it into the New River in times of shortage. They were working on the same idea in South London but I don't know what happened there — it seems to have gone quiet but I may just be out of the picture.

DE - That's the one I meant - thanks for putting me right. Every time I talk about reservoirs someone asks why not ASR instead. If it were as good as people imagine, wouldn't Thames (and/or Essex & Suffolk, who also have what looks a promising location) have done it by now?

MP - The problem with Essex/Suffolk was always going to be that the Chalk in that area is known to be tight.

"What about green water issues?"

DE - Serious as less recharge is, my main worry isn't about blue water at all (whether ground- or surface-). It's the plants (**not** the aquifer, sorry!) which have first refusal of rainfall.

MP - As I said in my *Geoscience* piece, the soil is like senior management — however scarce the resource it top slices what is available to make sure it gets its share before passing the leftovers to the strata beneath!"

DE - Great analogy and good point. In yesterday's climate plants took all normal summer rain plus most available soil moisture. In tomorrow's climate PE will be bigger (plants need more) and R will be smaller (plants get less). For crops/natural environment already near the edge, that spells disaster. I think we will have to put groundwater/surface water distinctions aside and think much more about green water issues.

Conclusions

MP - Let's just add the following:
1. Groundwater storage is such a large and useful reserve that it is absurd to talk about not using it;
2. Reservoirs are tiny by comparison and seem to hold useful reserves only because they are generally sited in areas where they serve relatively small populations (e.g. northern England as opposed to the south-east) or are there to supplement groundwater supplies (e.g. Ardingly, Bewl);

DE - Rutland Water is as big as Lake Windermere, and it holds 130-odd million cubic metres. Not exactly tiny!

MP - 3. Reservoirs need to be filled with something — in the dry period of this winter and spring, some had to be given special consents to be topped up from rivers that were already suffering low flows! Others use pumped storage from groundwater-fed rivers.
None of this is to say that we don't need to do something. We do not need a 'national water grid' as favoured by many of the public but we do need a national water plan, which has been sadly lacking since the demise of the Water Resources Board in 1975.

DE - You fill them from the high flows of normal winters. There's no overall shortage - nature gives each of us in England & Wales an effective rainfall of 3,600 l/day on average. You just need enough storage to cover extended dry periods like the present one.

MP - None of this is to say that we don't need to do something. We do not need a 'national water grid' as favoured by many of the public but we do need a national water plan, which has been sadly lacking since the demise of the Water Resources Board in 1975.

DE - Yes, absolutely.

But what do the rest of you think?– Ed.

Diary

2nd July 2012
Water, For All, Forever - Managing Water Locally
BHS National Meeting
Time: 10.30
Location: Newcastle University
Contact: Claire Walsh (Tel: 0191 222 6618)

9–11th July 2012
BHS 11th National Hydrology Symposium
West Park, University of Dundee
Contact: Dr Christian Birkel (Tel: 01224 272000)
bhs2012@abdn.ac.uk
www.abdn.ac.uk/bhs2012
or use direct links on the BHS web site.

25 –27th June 2012
'Stakeholders, next generation models, and risk in managing catchment change'
Catchment Change Network International Conference at Lancaster University, UK

The CCN conference will be followed directly by the celebratory workshop GLUE: 20 years on which will continue through to Thursday lunchtime.
Catchment Change Network
Lancaster Environment Centre
Lancaster University
Further details from: marion.walker@lancaster.ac.uk
Tel: (01524 510290)

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

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■ Web pages: **http://www.hydrology.org.uk/**

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