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Small-scale Hydropower — BHS comments on environmental issues

Continuing the BHS interest in the hydrological aspects of hydropower generation (see *Circulation* 32 for the report on the recent meeting in Glasgow), we reproduce here copies of correspondence between the President and the Department of Energy. For those not so well-versed in the issues at stake, we were pleased to receive a short article on the topic by Richard Hackett which is printed on pages 2 and 3.

Letter from ***Allan Lambert*** *to The Hon* ***Colin Moynihan*** *MP, Parliamentary Under-Secretary of State for Energy*

16 October 1991

Dear Mr Moynihan

Energy Generation from Renewable Resources: Hydropower

Following discussions with members of the British Hydrological Society's Main Committee, I thought you may wish to be informed as to some important conclusions arising from a Joint One-day Meeting between the British Hydrological Society and the Scottish Hydrological Group of the Institution of Civil Engineers held in Glasgow on 14 June (Report in *Circulation* 32).

The DoE initiative in introducing the Non-Fossil Fuel Obligation has resulted in the revival of medium and small sized hydropower schemes under the 1st and 2nd tranches (see Shaw's paper) and there was a general consensus at the meeting that the 3rd (and subsequent) tranches would tend to attract, and make economically viable, numerous small schemes.

The Non-Fossil Fuels Obligation will generate environmental benefits in one obvious sense (reduction of greenhouse gases), but there is another substantial environmental benefit illustrated by the Roadford example (paper by Whiter & Stewart). During the early promotion of this scheme, there was much concern and discussion regarding the release patterns from this regulating reservoir to the river downstream, and its effects on Salmonoid fisheries. Under the former energy tariffs, it was in the reservoir operators' interest to try to maximise income by short, high-rate releases at peak generation times, but such practice would produce environmental conflicts in the river downstream, caused by sudden changes in river levels, velocity, wetted area, habitat and water quality.

The fact that South-West Water plc was able to make a successful application under the DoE scheme, and obtain a flat rate tariff for the sale of electricity from hydrogeneration, has transformed the situation: the plc and the National Rivers Authority can now work cooperatively in ensuring that the releases can be environmentally friendly in river management terms, and a potential source of protracted disputes between river interests and reservoir operator has been eradicated.

I am sure that you would find, if your Department researched this, that the cause of many previous river management problems associated with other existing hydro-electric schemes on river regulating reservoirs in England and Wales has been greatly moderated for schemes accepted under the 1st and 2nd tranches.

I thought you would be pleased to learn of this additional benefit; but it also contains the seeds of potential future problems for the river environment, if the flat rate tariffs should be withdrawn after 1998. Many of the small hydro schemes which are being encouraged now under the NFFO would, in all probability, only be economically viable under 'traditional' tariffs if they were to be operated purely to maximise income, without regard for the river environment. Thus every scheme now encouraged is a potential future problem for the National Rivers Authority and the Scheme developers possibly before the end of this decade, if the flat rate tariff is to be subsequently withdrawn. With a large number of small schemes, the incidental costs arising from such conflict could be out of all proportion to the short-term benefits of hydro-power for a few years, and could set back river management in the UK significantly.

There will, of course, be some hydro schemes which, because of their location, the National Rivers Authority is unlikely to be concerned with. However, in the majority of cases, if the basic duration of the flat-rate tariff

could be subject to a guaranteed extension - provided there is an Agreement between National Rivers Authority and the Generator that such an arrangement is necessary to protect the river environment - then an opportunity will exist for increased hydropower without increased conflict in the future. I am therefore writing to you to respectfully suggest that this proposal might be discussed at an early date with the National Rivers Authority.

You may ask, why should the British Hydrological Society be concerning itself with this matter? Although other important environmental matters such as Climate Change and Low Flow Management are at last receiving due attention nationally, the BHS Main Committee has agreed that the problem I have drawn to your attention has not been identified elsewhere, so it is appropriate to take the exceptional step of writing to you directly. As an interdisciplinary society, our members see the adverse consequences of unavoidable conflicts in river management often enough, and wish to play their part in identifying and reducing avoidable sources of conflict. For myself, I have worked for River Boards, River Authorities, Water Authorities and Water Supply plcs for almost 30 years; I have chaired the statutory Dee Consultative Committee, and acted as Consultant to the Norwegians in trying to assist in resolving serious river management problems arising from their hydropower development. This is the first time I have felt moved to write to a member of the Government during my 2-year term as President of BHS.

Should you require any further information or discussion, please let me know, and I will be pleased to assist in any way possible.

Yours sincerely

Allan Lambert,
MEng, FIWEM, MICE, FAWO
President, British Hydrological Society

Reply from ***Colin Moynihan*** *MP:*

13 November 1991

Dear Mr Lambert

Thank you for your helpful letter of 16 October, commenting on the benefits which the Non-Fossil Fuel Obligation (NFFO) is bringing, through the regulation of water flows in small-scale hydro power schemes.

As an angler myself, I can understand the conflicts which might be caused by high-rate releases of water at peak generation times. Your comments on the environmental benefits arising from the implementation of NFFO were very constructive and I have asked my officials to take up this point directly with the National Rivers' Authority, with specific reference to the Roadford scheme.

In your letter, you referred to the question of flat rate tariffs beyond 1998. The Renewable Energy Advisory Group of which I am Chairman, is looking generally at the question of the future strategy for the promotion of renewable energy in the United Kingdom and the 1998 limit in particular. Your remarks are therefore a welcome contribution to the debate.

Yours sincerely

Colin Moynihan

Small-scale Hydroelectric Power Development

The recent increase in public environmental awareness coupled with ever increasing fuel prices has stimulated the need to invest in renewable energy sources. As part of the 1989 Energy Act, the Government introduced the Non-Fossil Fuel Obligation (NFFO) whereby regional electricity companies are obliged to secure a set quota of energy from renewable sources. Under the Obligation, a higher tariff is available for the export of electricity to a local or national grid. Currently, hydro developers are being paid 6p/kWh which is approximately double the rate being offered by the National Grid Company.

Small hydro sites may be developed using compensation releases from reservoirs, weirs and waterfalls, pressure reducing valves in water supply networks and outfalls from sewage works.The technology involved with the development of a hydro-electricity site is well proven and equipment is commercially available. Thus, hydropower is one of the easiest sources of renewable energy to develop and compares favourably to other renewables such as wind power and wave power which are still undergoing technical development.

The power output for any scheme will depend on the head and flow rate and is given by the formula:

$$P = \rho g h Q \eta$$

where: P is the power output (W)
ρ = 1000 kg m^{-3}
g = 9.81 m s^{-2}
h = net head (m)
Q = flow rate (m^3 s^{-1})
η = overall scheme efficiency

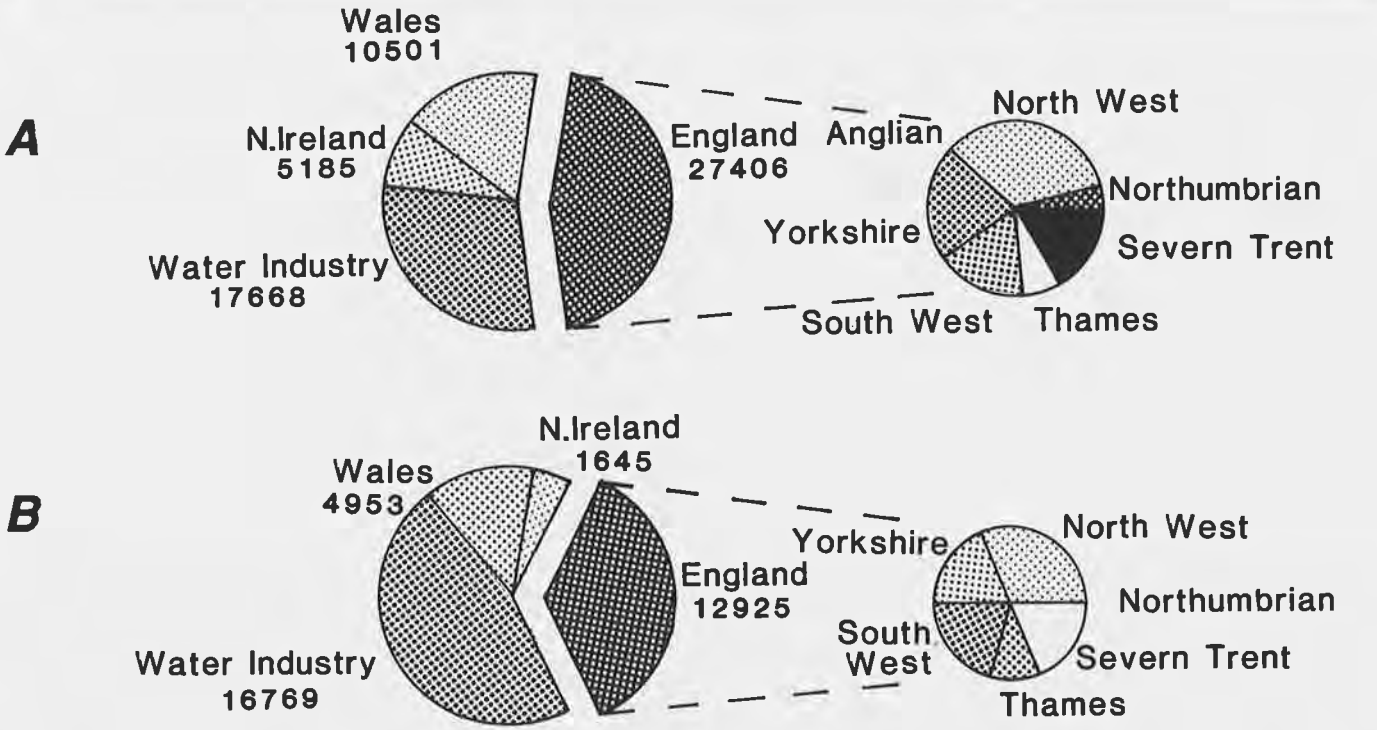
The predicted revenue will depend on the accurate assessment of the discharge through the turbine. For reservoired schemes, this will be determined by the operation policy of the reservoir and the required compensation flow. For run of river schemes, the flow duration curve (FDC) is used to predict the annual discharge through the turbine, from which the power output can be calculated.

Deriving the FDC at a Hydro site is not always straightforward. If a nearby gauging station exists, data from the station should produce a reliable FDC from which the scheme economics can be assessed. However, if a synthetic FDC has to be derived based on regression formulae involving catchment characteristics, the developer should be aware of the limitations of the formulae and the possible errors associated with the results. It may be worthwhile applying the regression formulae to a similar gauged site and comparing synthetic data with gauged data.

When this procedure was carried out for several stations in the Northumbrian Region using the Low Flow Studies report, the errors involved with the estimation of low flows were significant. This has particular importance in evaluating the economics of the scheme and in determining the reliability during dry periods.

Turbines

Small hydropower stations are site specific and must be designed as "one-offs". The chosen turbine should be



Distribution of capacity (kW) by water authority area for run-of-river schemes in England with IRR ≥ 5% (A) and ≥ 10% (B)

capable of harnessing the maximum power from the water under the given range of flow conditions.

Turbine selection and specification is best left to manufacturers who can advise on the strengths and weaknesses of their machines. The choice of which turbine to use normally depends on the head. Impulse turbines such as the Pelton Wheel or the Turgo Impulse Turbine are suited to high heads of 30m to 40mand more. Reaction turbines, characterised by the Francis and Kaplan machines, generally operate at heads from 10m to 200m for the Francis Turbine and 3m to 50m for the Kaplan Turbine. The Cross Flow Turbine will operate at heads from 3m to 100m and is able to maintain a constant efficiency over a wide range of discharges. This makes it particularly suited to run-of-river developments.

A number of variations exist on the standard designs, one of which is a modular plastic turbine developed by Water Power Engineering. This comprises of a moulded plastic turbine housed in a structure and the forces exerted by the water are very small. This allows civil works to be kept to a minimum with simple concrete bases being sufficient for the inlet works and the turbine housing. The turbine has only recently been developed and, to date, only a demonstration model is in operation.

Economics

Initial scheme assessment can be made relatively easily using discounted cash flow techniques. However, a more detailed scheme appraisal should take account of interest repayments on borrowed capital, operation and maintenance costs, taxes and local authority rates.

Securing a contract under the NFFO is critical to the financial success of many small schemes. A recent study on the Non-Technical Barriers to hydropower development recommended that a minimum period for the NFFO should be 15 years. However, at present, the incentive is due to end in 1998 after only 8 years of operation.

Practical Considerations

A few small hydro stations have been developed either without a full understanding of the hydraulic behaviour of the river or with insufficient finance to carry out a proper job. This has resulted in the schemes not reaching their full predicted output and remedial works having to be carried out to improve the power output.

It is particularly important to be aware of the flow characteristics of the river, both at high and low flows. The intake structure should be sited in a position that will permit the design discharge to enter the penstock pipeline. Care should be taken to avoid flow separation around the intake which will reduce the quantity of water entering the pipeline. Also, the intake should not be located in a position where flood flows will be channelled into it.

Supply reliability is another important feature of a development, particularly for stand alone schemes which are generating electricity for a single dwelling or factory etc. For run of river sites, when flows are low during summer months, output may need to be supplemented with a diesel generator.

An alternative to this is to combine renewable resources by using wind, solar and hydro power to provide a reliable supply under most conditions. This principle is being employed at Consett in County Durham where a number of lakes on a new housing development are intended to provide pumped storage energy which will be used in conjunction with a new wind power development.

Hydroelectric schemes tend to be long term investments with high initial cost. The only financial help for new developments is available from the Energy Technology Support Unit (ETSU), funded by the Department of Energy. They can provide funding for up to 50% of the costs of a feasibility study. Nevertheless, small hydropower stations can be sound financial investments, particularly with an NFFO contract for the sale of electricity to a grid network.

Further information on small hydropower development can be obtained from the National Association of Water Power Users, ETSU or specialist manufacturers and consultants.

Richard Hackett

Third National Hydrology Symposium

These reports of the six sessions of the Southampton Symposium in September summarise the highlights of the presentations and the discussions which they engendered. Ideally they should be read in conjunction with the published proceedings.

Session 1 – Demand Management & Forecasting

The Chairman, **Barry Gardiner** of Southern Water services, introduced the session by emphasising the need for accurate demand forecasting since the Water Industry in particular has to balance the needs of its customers in terms of provision of services against the needs of the customers in terms of the environmental impact. These were not necessarily compatible, especially when cost was taken into account.

Peter Herbertson of NRA Southern delivered the keynote presentation. He set out the role of the NRA to conserve, redistribute, augment and secure all proper uses of water resources. This was different from the role of the Water Companies, who had a duty to care for the environment. Peter also identified the need to change methods of paying for water against the backdrop of drought covering a good part of the country during 1989 and 1990 with some areas still being affected in 1991.

He went on to give the history of demand forecasting, showing the developments that have taken place from the early days of trend forecasting to the component analysis undertaken today in its various forms, and rounded off his entertaining and provocative keynote speech by inviting forecasters in the 1990s to "go to it".

Peter Shaw of NRA Southern presented the current NRA method of demand forecasting which broke down water consumption into detailed component parts. The clever bit was the distinction between various types of properties by means of the Acorn Classification. Acorn is a method of providing socio-economic groups derived by CACI Market Analysis Ltd., which basically identifies the different types of properties. Consumption for the different types of properties is derived from control areas set up in the NRA Southern Region.

Allan Lambert then delivered a paper on Regional Variations in Demands for Water and Realistic Leakage Targets. Allan, with his wealth of experience in water generally, presented the overall picture of water consumption growth (taken from published material). There had been 13% growth in the period 1975 to1987, with peaks occurring in winter as well as summer because of freeze-and-thaw weather conditions. Whether this would be a problem depended on the part of the country being analysed. Alan referred to work on improving our understanding of leakage targets and demands.

As a contrast to Peter Shaw's paper, **Colin Fenn** presented the results of some detailed analysis undertaken by **Angela Gurnell** and himself for Southern Water Services on the control areas in Hampshire. Colin went through the mechanism that had to be designed to filter out rogue or bad data before coming up with a short-term forecasting model for the prediction of water demand in Hampshire. Colin and Angela's paper did question the Acorn Classification System's accuracy.

A further development of residential water demand analysis was presented by **Mike Hall** (Middlesex Polytechnic). He used fuzzy regression analysis to establish the relationship between residential *per capita* demand for water and unit price, using data from cities and towns in the USA and Australia to illustrate the sensitivity of the results and produce an upper and lower limit to the estimate. This difficult subject was put across in an entertaining way, but whether the audience could grasp it in such a short time was in doubt.

The final paper, presented by **Colin Fenn** and **John Bircumshaw** for companies within Southern Water plc, gave the practical application of demand forecasting and the development of the major scheme for water resources in Hampshire. Being able to hear a practical application focused the audience's minds upon what the session was all about: i.e. providing sufficient water for people's needs.

In the summing up and discussion, Barry Gardiner indicated just how much work will need to be done in the future to justify resource development and to minimise impact upon the environment in which we live. This presents a social problem in terms of balancing the provision of water for all needs against the provision of water for essential needs, an area of debate which will no doubt run and run.

Barry Gardiner
Southern Water Services

Session 2 – Low Flow Management

The low flow management session, which ran in parallel with other sessions over a whole day, allowed a broad examination of the problems and solutions associated with low flows. It was split into four parts centring attention on different aspects of the topic: the morning session was chaired by **Clive Swinnerton** (NRA HQ), followed in the afternoon by **Mike Mansell-Moullin** (Consultant).

Part 1: Perspectives on low flow problems.

The first session was opened by **Jerry Sherriff** (NRA HQ), who examined some of the problems of defining and then alleviating a low flow situation. He outlined work which had produced a list of the top 20 rivers affected and demonstrated that the solutions to these low flow areas were far from simple, with conflicting needs for water use, and most of the low flows resulting from legal abstraction, especially from groundwater.

Next, **John Mawdsley** revealed the scope of the forthcoming *BHS Occasional Paper No.3*, covering subjects involved in the assessment of drought severity. **Peter Herbertson** (NRA Southern) asked whether the combined problems of low winter rainfall and hot summers would be considered: the reply was that it may be included if there was sufficient interest. **Chris Binnie** (W. S. Atkins) asked if groundwater droughts would be assessed, to which the reply was yes.

Cathy Glenny and **Jane Kinniburgh** (NRA Thames) described the methods used in low-flow management of the Lower Thames, examining the conflicts involved in managing the situation and showing the need for an integrated approach to the problem. The Thames Drought Management System had been designed to try to keep to a series of target flows and water quality standards. The question posed by **David Evans** (NRA Anglian) was, "Are we over-exploiting the Thames; if so would Thames Water agree?" The answer given was that it is difficult to define over-exploitation, and that the NRA was working with Thames Water in an effort to keep the river system in balance.

The final speaker in Part 1, **Alan Gustard**, outlined the advances in low flow estimation and impact assessment that have been made at the Institute of Hydrology. He was asked by **Cliff Dobson** (NRA Severn Trent) if the use of Micro Low Flows increased in situations where there are artificial influences; the reply was that there was no reason why this should not occur.

Part 2: Operational aspects opened with a paper on the optimisation of system demand by linear programming by **Antony Tollow** (University of Durban-Westville South Africa). This system had been applied to optimise the operation of reservoirs in South Africa and its success has been determined using the "credibility index". **Graham Thompson** (Binnie & Partners) asked how the outputs from the system were put into practice: the reply was that the steps used so far in the model were manual, monthly and designed to solve certain problems. The work had been done independently of the operators and had not yet been used, but when the results are finalised they would be put to the operators.

Cliff Dobson and **Richard Cross** described the use of spreadsheets and microcomputers to simulate release strategies in the droughts of 1989 and 1990. They were asked by **Richard Streeter** (NRA Headquarters) if there was a consultative group for the River Severn. There was not one yet because the system was so large and complex, but the situation had been helped by frequent meetings with the major abstractors and through being able to show the success of the model in aiding the release strategies. **Chris Binnie** (W. S. Atkins) inquired how the Bewdley Gauge was chosen for use in the work instead of a gauge nearer the tidal limit. He was told that the gauge was halfway between the release area and the tidal limit and that the influence of inputs and abstractions further downstream, already catered for in the current model, might be impractical and might make the model unnecessarily complex.

Alan Weston and **Brian Hodgson** then detailed the River Aled regulation system, designed to reconcile the problems caused when dry summers and increasing demands for water led to widespread application of Drought Orders and a dramatic reduction in residual flows, with an unfavourable impact on fisheries. The solution has been achieved through the formation of a Consultative Group working under an Operating Agreement.

Terry Newman and **Richard Symonds** ended the morning with a case study of the River Allen. Once a classic habitat for trout and an exemplary chalk stream, it is believed to have suffered from the groundwater planning techniques of the 1960s and 1970s. NRA Wessex region are now addressing these problems through the use of computer models, fisheries and biological studies as well as specific instances of flow depletion. The case of the Critchel Lake was queried by **Elfyn Parry** (NRA Severn Trent Region) who asked what the solution was to the low water levels found here, and also asked if the NRA should know which abstraction licences could be permanent. Dr Newman responded that negotiations would have to take place to address the problem, as there were no operating rules on the licences to ensure efficient operation and no specified minimum level for the lake. He added that the NRA was now counting the ultimate cost of past groundwater development.

Part 3: Environmental issues

Hilary Smithers described the low-flow management procedure being developed for the River Derwent to support abstractions near Workington. Historic and current data had been analysed to develop a regulation procedure controlling a river which is unusual in two respects: the releases into the system are small and infrequent, and there is a natural lake between the release point and the control point. This has led to the use of wide margins of error in the procedure, but it should provide a good foundation for future work.

Peter Midgeley and **Charles Jones** gave a further insight into the problems of low flows in chalk streams, with a paper describing the rehabilitation of the Wallop Brook and Bourne Rivulet. **Terry Newman** (NRA Wessex region) asked the speakers at what point the techniques used in the work had begun to be questioned. The reply was that the final quality control needed refining and was better in some areas than others. The NRA also has the problem of demonstrating what is a natural flow: the NRA could not, and should not be expected to, improve on a natural system. As far as the models were concerned, the results are as good as possible and public acceptance of the output has been improved by the prediction of past events.

Rob Brown, Nigel Ironside and **Sally Johnson** then demonstrated how an environmentally acceptable flow regime (EAFR) for the River Darent had been achieved through an ecological and hydrological survey. This identified an area of the river which had a good natural chalk stream ecology, Shoreham, and then produced an EAFR which could be standardised by catchment area to other sites on the river. Rob Brown was asked whether Shoreham's condition would be better if it had a normal flow regime, rather than a possibly depleted one. He replied that since the BMWP was better than that predicted by RIVPACS the river was probably in as good a condition as it could be.

Andy Bullock and **Ian Johnson** ended the environmental issues section with an outline of the application if the Instream Flow Incremental Methodology (IFIM) in the UK. The IFIM was initially applied to two rivers, the Blithe and the Gwash, and is currently being developed in a research project funded by the NRA for the setting of ecologically acceptable flow regimes in England and Wales. The Chairman **Mike Mansell-Moullin** asked how long the research programme would go on before a useable approach was found. Andy Bullock agreed that a two-phase approach might be necessary, part one giving an initial estimation and part two giving a more defined answer. However, he would be pleased to carry out work now. Terry Newman added that the work was based on flora and fauna and not yet on other needs, but at the end of the day a technique should appear: the field of knowledge is still being developed. **Graham Thompson** (Binnie and Partners) asked how populations of a diverse number of species could be predicted with PHABSIM, the reply being that you would select a hierarchy of species or produce curves for habitat diversity.

Part 4: Future prospects

In the final section **Hugh Goldsmith** and **Elfyn Parry** examined the short- and long-term options for low flow alleviation. The short-term approach may involve technical solutions combating problems in specific reaches. The long-term solution will develop integrated management plans with the cost being paid by the consumer.

Geoff Petts closed Part 4 by detailing research needs for ecologically-sound low flow management, illustrating the need for a multi-disciplinary approach to the subject including ecology as well as hydrology and other aspects. **Terry Newman** developed the issue of hydraulics being the dominant feature over hydrology, suggesting that in many cases, especially chalk streams, the two were inextricably linked. The reply was that, although hydrology is the driving force, under low flows the channel morphology makes a great difference to the ecology and may therefore be more important. **Allan Lambert** (Welsh Water/Wallace Evans) referred to hydropeaking becoming more of a problem to ecology with the encouragement of small hydropower schemes. Geoff Petts answered that in the USA some schemes have been stopped because of this and that there are similar problems with water releases designed to produce white water for canoeing.

The low flow management session was bought to a close by **Professor Brian Wilkinson** (Director, Institute of Hydrology), in place of John Rodda, with a paper on Future Prospects for Hydrologists. This anticipated the United Nations Conference on Environment and Development and looked at the role of hydrology in addressing perceived environmental problems already faced in developing countries. Professor Wilkinson examined the central place occupied by hydrology in the modelling of climate change with programmes such as the Global Energy

and Water Experiment, and the strength of the UK's contribution to hydrological modelling, especially in problems of scale, data validation and manipulation, remote sensing and meteorology.

Craig Elliott
Institute of Hydrology

Session 3 – Hydrograph Separation

Your reporter has attended many BHS meetings since its formation in 1983: disappointingly few of these have been memorable. Some have been remembered for the wrong reason, for example because the journey to the meeting was made through a raging snowstorm, the refreshments were good, or the car was broken into. At too many meetings there have been speakers with either no message or no desire to expand the audience's horizons.

Two meetings, however, have stood out for many years as excellent examples of what BHS should be aiming for. The first was the meeting on 'Statistical Flood Estimation' at the University of Newcastle upon Tyne in June 1984. I refer you to *Circulation* 3 for a report on that meeting, but I remember the very lively discussion that followed from new techniques advocated by Mike Acreman and Steve Wiltshire, and from the outsiders' comments made by Eric Wood and Jim Wallis on the FSR statistical method of design flood estimation.

John Hollis's 1986 talk to the BHS Southern Section on 'The interpretation of soil survey data for hydrological practice' will be remembered for his clear and well-illustrated presentation, pitched at the general hydrologist rather than at the soil scientist. To this short list of excellent meetings (and I am sure you all have your own) I shall now add this symposium session on 'Hydrograph Separation'.

Keith Beven's message as keynote speaker was simple: "don't". However, the following speakers all ignored his advice and did so, with very different results (see the published proceedings). This led to a very lively discussion about the very nature of catchment response to rainfall. Are flood hydrographs caused by new water displacing old water held in storage (as suggested by **Alice Robson**'s chemical analysis), or did the rainfall find a quick response pathway through the catchment and constitute the major portion of the flood (as advocated by **Ian Littlewood**)? While no one could answer this question, a most enjoyable time was had by all as we listened to the many points of view. This subject was clearly of interest both to the traditional unit hydrograph modellers, who use separation as an expedient to develop techniques to solve real problems, and to those concerned with inner workings of catchments at the process level.

While many agreed that hydrograph separation techniques had served practising hydrologists well in the past, it had to be recognised that the partitioning of flow could not be justified physically. No separation into distinct components - be they old and new, quick and slow, or deep and shallow - came close to representing the complexity of catchment response. Although it was interesting to examine separations based on tracer or chemical studies, it was dangerous to make assumptions about physical processes based on the results. Indeed one speaker thought that these studies were, in some ways, setting hydrological thinking back 30 years, since they appeared to be offering support for the use of models based on hydrograph separation.

Other issues raised in the debate included the appropriateness of two-component mixing models, the relative merits of different tracers, and the variability in derived separations, both between events and between catchments, even when using a single technique.

All those who contributed must be applauded for the enthusiasm and passion with which they presented their arguments. How refreshing to have such an animated discussion on the fundamental concept of how catchments work, and on the way in which the modeller's beliefs affect the choice or structure of the catchment model.

David Boorman
Institute of Hydrology

Session 4 – Unusual Hydrological Events

Although this session included a review of recent volatile climatic conditions (**Terry Marsh** and **Sue Bryant**) and presentations about extremes of flow, rainfall, soil moisture deficit (**Paul Rosier**) and snowmelt, the discussion revolved almost entirely around rainfall.

Following on from **Mike Acreman** and **Vin Collinge**'s paper on the Calderdale storm and **Dave Archer** and **Dennis Wheeler**'s paper on heavy rainfall in northeast England, the discussion started with **Peter Wolf** (City University), **Chris Collier** (Met. Office) and **Mike Lowing** (Watson Hawksley) considering conflicting estimates of maximum rainfalls between point raingauges and weather radar, the radar generally showing less — or sometimes no — indication of rain (e.g. Walshaw Dean Lodge, 19 May 1989). Several examples were cited where the Met. Office had not believed the point estimate, and had on occasion even reduced it by a seemingly arbitrary amount without any consultation (e.g. Feldon Burn, 24 August 1990). Chris Collier suggested that raingauges and radar should be complementary rather than competing systems, particularly with their associated accuracy problems. The Met. Office accepted or rejected extreme point raingauge readings on the basis of near-neighbour analysis, but he accepted that they were wrong sometimes to reduce the depth of rain recorded without annotating the modification accordingly.

Cliff Dobson (NRA Severn-Trent) agreed that weather radar was important for filling in gaps in the raingauge network, and commented that statistical analysis of rainfall in the Flood Studies Report (FSR) had not used weather radar data. Chris Collier suggested that the FSR methods of estimating extreme rainfall depths needed to be revised as they were based on insufficient data. Cliff Dobson pointed out that it was only recently that people had recognised the need for fine-resolution radar data. In view of the fact that radar was an areal estimate whereas raingauges were point estimates, and that areal reduction factors were different for extreme convective and frontal rainfalls, he questioned Mike Acreman and Vin Collinge's point rainfall reduction of only 10% when converting to a catchment areal value, and hence pointed to the need for research into areal reduction factors for different synoptic situations. Chris Collier remarked that work was being done, but through other applications rather than as pure research. **Dave Archer** (NRA Northumbria) reiterated the point, saying that the chances of a particular raingauge covering a storm's maximum intensity were small. Chris Collier considered that in such circumstances, i.e. short duration, high intensity rainfall, it was possible that a probable maximum precipitation could be exceeded. Dave Archer suggested that frequently for storms of large lateral variation what was lost by underestimating the intensity was gained by applying an areal reduction factor, so current probable maximum precipitation estimates might not be unreasonable.

Duncan Reed (IH) returned to the subject of rainfall frequency analysis and the problem of storm-centred analysis versus catchment-centred analysis in design. It was desirable that all aspects of FSR rainfall frequency statistics were looked at again. He and **Lisa Stewart** (IH) were soon to resume rainfall frequency work using daily, and some hourly, data in England and

Wales. Some areal reduction factor work by Lisa Stewart had previously been presented at the IAHS Baltimore conference. Peter Wolf wondered if we should really be looking at the physical structure of storms, as well as at rainfall statistics, in order to help engineers. **Ron Manley** (consultant) proposed that for extreme events the numbers for models were best estimates from a fuzzy data set, i.e. limited in scope and prone to measurement error, and that we should be considering fuzzy probabilities of rainfall events. Chris Collier mentioned fractal analysis as another interesting idea with a possible application. Mike Lowing asked if the recommendations in Lisa Stewart and **Nick Reynard**'s paper on rainfall profiles for design events of long duration would be published, for instance in the form of a Flood Studies Supplementary Report (FSSR). Lisa Stewart replied that recommended design profiles for the northwest Scotland study area and northwest England would definitely be published, but the form of publication had not yet been finalised.

Helen Houghton-Carr
Institute of Hydrology

Session 5 – Snow and Ice

This session largely dealt with recent developments in glacio-hydrology, together with the more applied aspects of snowmelt hydrology. **Martin Sharp** (Cambridge University) gave the opening address, reporting on the potential for water quality to define the hydrological character of alpine glaciers. Referring to a joint project with Southampton University on the Upper Arolla Glacier, Switzerland, the way forward for modern glacio-hydrological investigations was described, with reference to the independent establishment of hydrological conditions under the ice. The second presentation by **Michael Clark** (Southampton University) described the use of inferential observations at the glacier snout as an input to the research mentioned above. Such observations, based on sedimentological and hydrochemical data, described well the evolution of the glacial hydrological systems, allowing the recognition of five distinct phases in drainage evolution and stepped progression from one to another.

The remaining addresses dealt with snowmelt, with **Richard Harding** offering an insight into some of the problems associated with physically-based snowmelt models. Field investigations in maritime, continental and arctic maritime locations revealed how 15-20% errors may arise when adopting energy balance approaches.

John Mawdsley (NRA Northumbrian region) presented an interesting assessment of the current treatment of snowmelt as a flood-generating medium. Fieldwork in northern England revealed that the maxima of snowmelts for these locations are probably far in excess of those disputed in previous BHS meetings, and also greater than those incorporated into current flood models.

Continuing with snowmelt flooding, **Mark Futter** (Kingston Polytechnic) reported on the derivation and working of a statistical model designed to predict flooding probabilities with respect to antecedent baseflows. He concluded that snowmelt not only modifies the peakflow characteristics, but is responsible for the generation of more events.

The last address was a welcome addition to the session by Swedish hydrologist **Jörgen Nilsson**. His address was concerned with the applied problems of hydrological management during the winter months, when snowfall and the freezing of the country's waterways created a whole new suite of problems.

Andrew Hodson
GeoData Institute,
University of Southampton

Session 6 – Large databases for hydrology

In his introduction to the final session the chairman, **Mike Lowing** (Watson Hawksley), drew attention to two important aspects of large databases for hydrology. The first focus was essentially technological, concerning the problems of storing an increasing volume of both high resolution and summary data in ways which would permit easier access for all kinds of potential users. The second lay in the opportunities for new methods of analysis which had been opened up by the very existence of user-friendly databases, whether or not they were fully integrated.

From his experience of the administration and use of databases, Mike Lowing highlighted the need to include, alongside the values themselves, sufficient commentary to enable future users readily to appreciate precisely the attributes and quality of the stored data. He also suggested that national standards for the specification of data quality were long overdue, and that without such standards even the most elaborate systems of data annotation could fall into disuse when staff moved.

The keynote paper by **Mike Clark** and **Angela Gurnell** (GeoData Institute, Southampton University) was distinctive in that it considered general issues relating to the design and use of large databases, and referred to the subsequent presentations for specific case-studies. Looking to the future, the paper echoed several of the chairman's points, referring to the scope for enhancing database quality in most disciplines. The need for increased awareness of operator, instrumental and system variance in data collection was addressed, and a plea was made for agreed definitions of hydrological indices, and for a set of consensus format and documentation standards. It was suggested, and reinforced in subsequent discussion, that professional societies such as BHS have a major role to play in setting and implementing such standards.

Many of these introductory issues were supported and strengthened through the exploration of the HOST (Hydrology of Soil Types) data set by **David Boorman** (Institute of Hydrology), **John Hollis** (Soil Survey and Land Research Centre) and **Allan Lilly** (Macaulay Land Use Research Institute). This highly significant project demonstrates the scope for producing powerful indices for secondary data sets, but also highlights the problems of achieving a data audit within the process of integrating information from such varied sources. Ultimately, of course, it is the use of the data that establishes the value of the database, and in this context **Alan Gustard**'s (Institute of Hydrology) demonstration of the scope for developing low flow indices from the FREND (Flow Regimes from Experimental and Network Data) database was a convincing exposition of both the potential and the problems. Despite the considerable challenge of building a consistent international database, Alan established a clear justification for the effort by showing the power and generality of the derived relationships.

Although both these examples recognised data quality as a critically important concern, both also lead to an awareness of the importance of a technically robust and access structure. A pragmatic approach to such problems was displayed by **Yvonne Parks** and **Kevin Sene** (Institute of Hydrology) in their treatment of the development of data import and export functions for the HYDATA hydrological database. They argued the importance of overcoming the often difficult barriers to data import, which reduce the effectiveness of both the database and the data acquisition technologies.

Two examples of major archive systems were discussed during the session. The national archive of flood event data for the UK was considered by **Helen Houghton-Carr** and **David Boorman** (Institute of Hydrology), with examples of output analysis being used to demonstrate the very wide range of applications for this database. Even

broader in scope and larger in scale was the new national hydrological database for Norway described by **Lars Roald** and **Stein Beldring** (Water Resources and Energy Administration, Norway). As well as presenting the types of data involved, the authors discussed the decision process used to select an appropriate database and to design an appropriate data model.

With a continuing increase in scale, **Chris Collier** (Meteorological Office) discussed the nature and reliability of the COST-73 Weather Radar Networking Project database for the European Community. The coarse resolution of this database generates grave difficulties in representing variations in soil properties and infiltration, so these processes have to be parameterized — albeit with considerable difficulty. Nevertheless, the paper was able to construct a strong case for the use of such data in continental scale hydrological studies. A technical challenge of similar magnitude is that associated with the biasing effect that data discretization has on the estimation of extreme values (**Andrew Coyle, Bruce Kelbe, Duncan Reed** and **Lisa Stewart**, Institute of Hydrology). These effects are becoming more readily available for study as a direct result of improved data acquisition and storage systems.

The session as a whole demonstrated a strong commitment to large databases, but also raised the question of whether we might be overselling their advantages. This danger was recognised, but was countered by factors such as the ability of such databases to attract funding and support, their role in attracting teams of complementary skills, and their ability to force us to confront general issues that might be overlooked with small databases.

The all-pervading importance of data documentation was fully explored in discussion. Without a range of ancillary information concerning not only the data but also the full range of associated hydrological and management conditions, it was deemed unlikely that data could retain long-term value. The collation of ancillary information should be given high priority, but its cost presented real difficulties and there might be technical problems in archiving it efficiently. More generally, data standards were seen as offering greater analytical robustness, and also a path to data portability and to hardware/software independence. Past efforts in this direction, for example by the IAHS, had been superseded prior to completion, and a possible role here for BHS was stressed.

Finally, the session highlighted the broad and increasing problem of the commodification of information. The substantial differences in national policy towards this constraint on data use were discussed, and the advantages of encouraging both data flow and value-added activities through at-cost access to public domain data sets were addressed. Such a policy did not reject the notion that the public sector should recover the initial data acquisition costs, but noted the success of the USA in progressing this recovery through the enhanced tax return on the economic activity generated by value-added ventures. Here again the importance of professional lobbying suggested that the BHS might see potential for involvement on behalf of the hydrological community. A session that had looked into the heart of database technique thus ended on a broad-ranging excursion through some of the major issues confronting the profession.

James Feaver
GeoData Institute,
University of Southampton

"After the Games"

Following an embarassing musical debut in Hull in 1987, I thought it best to avoid the Southampton Symposium's *Hydrological Games* (in which teams had to show how hydrology might be popularised in broadcasting), so I went home and watched television.

Members may be interested in the *Thames TV* schedule for that evening:

18.30 *Brookside*: After the Close is devastated by the flooded brook, inter-household arguments rage as to its return period, whilst Barry tries to shift 500 pirated copies of Micro-FSR.
19.00 *The Sweeney:* Popular 1970s hydrological disaster series (Sweeney Todd = act of God) starring Thaw and Waterman.
20.00 FILM: *The Road to Wigan Weir:* George Orwell's little-known sequel, inspired by a discarded page from the Lancashire Water Corporation's hydrometric handbook which he found on a Burnley tram in 1933.
21.00 *Book Choice*: including *The Good Weir Guide.*
21.15 *The Bill*: Drama exploring the effect of water metering on Isle of Wight family of six.
22.00 *Jim'll Fix It:* Intrigue set in 1980s research institute.
22.30 *The Avengers*: Cash-starved RPB acquires fleet of reconditioned cult 70s vehicles in mysterious deal.
23.30 FILM: *I was Bowman's Double* based on the true story of the man selected to impersonate the head of the NRA following a Home Office typing error which resulted in a broadcasting ban on representatives of the rivers watchdog.

Dave Morris

8th ANNUAL GENERAL MEETING

Institution of Civil Engineers, 2nd December 1991

Present:

Allan Lambert, President
Dr Mike Lowing, President Elect
Dr Susan Walker, Hon. Treasurer
47 other members

President's introduction

The President thanked all the members who were present, and noted that a BHS National Meeting would follow the conclusion of the AGM. No additional items had been received by the Honorary Secretary for inclusion on the Agenda.

Minutes of the 7th AGM held at the University of Birmingham, 10 December 1990

The minutes of the 7th AGM had been published in *Circulation 29*. There being no discussion of the minutes, Professor Peter Wolf proposed their acceptance. This was seconded by Mike Lowing and the minutes were duly approved.

Report of the Honorary Secretary

The full report of the Honorary Secretary had been published in *Circulation 32*, and therefore he only

highlighted particular points. The membership of the Society stood at 625 but of these about 104 had not yet paid their 1990 subscription. It was likely therefore that the number of members had actually fallen compared with the total of 589 recorded the previous year. Members were urged to encourage others to join the Society.

The programme of national and local meetings had been maintained throughout the year although the 2nd Postgraduate Hydrology Symposium had had to be postponed due to lack of interest. However the 3rd National Hydrology Symposium, held at the University of Southampton, had been a great success, being oversubscribed. It had proved to be an excellent show-case for hydrology, and the Honorary Secretary expressed the thanks of the BHS main committee to the organisers, in particular Dr Angela Gurnell of the University of Southampton and Dr David Boorman of the Institute of Hydrology.

Finally, the Honorary Secretary expressed his sadness at the sudden deaths during the year of Dr Vince Collinge and Dr John Pirt who had both in their different ways served hydrology and the BHS for many years. He concluded by adding his personal thanks for all the support and encouragement he had received from the outgoing President Allan Lambert.

Report of the Honorary Treasurer

Dr Susan Walker, the Honorary Treasurer, presented the income and expenditure of the BHS for the year ended 30 September 1991. In summary, the figures were:

Income:

1991	1990	1989
£26,554*	£9123	£14,102+

* including £ 15,210 from the 3rd National Hydrology Symposium
\+ including £ 7205 from the 2nd National Hydrology Symposium

Expenditure:

1991	1990	1989
£18,176	£7849	£16,044

Surplus (deficit):

1991	1990	1989
£8378	£1274	(£1942)

Dr Walker was pleased to be able to report the improvement in the BHS financial state. Clearly the Southampton Symposium had been a great help, and she expressed her thanks to the NRA for their financial support, and to all those who helped to make the Symposium such a success.

At the 7th AGM a year ago it had been necessary to increase subscriptions by more than the rate of inflation to cover the expected cost of the Membership Directory. However this year it would be possible to maintain subscriptions at their existing level, namely £18 for members and £9 for concessionary members. She felt that whereas when she took over as Honorary Treasurer the financial situation had been very vulnerable, it was now possible to release some funds for new initiatives.

The finances of the Society in the years ahead would be in the safe hands of the new Honorary Treasurer Tony Lewis. Dr Walker thanked staff of the ICE, particularly Mary McBride, for their help, and mentioned that increased revenue had also been received due to the efforts of Celia Kirby in arranging income from advertising in *Circulation* and of Allan Lambert through encouraging the further sales of the BHS Occasional Papers. The President thanked Dr Walker for all her efforts pointing out that she had transformed the finances of the Society. Mr Mike Knowles proposed the acceptance of the Report of the Honorary Treasurer. This was seconded by Dr Hilary Smithers and duly approved.

Report on Publications by the Editor of *Circulation*

Celia Kirby, the editor of *Circulation*, thanked the Director of the Institute of Hydrology for his continued support of *Circulation*. She also thanked her colleagues at the Institute of Hydrology, in particular John Griffin and Hilary Stevens who had successfully introduced desk top publishing techniques. Thanks were also due to the BHS membership for sending in copy: news, articles, information, etc.

Results of Ballot relating to Statues

The membership had been issued with ballot forms through Circulation for changes to the Statues concerning (a) revisions to the categories of membership and (b) voluntary use of the title Member of the British Hydrological Society (MBHS). The Honorary Secretary announced the results of the ballot as follows:

Changes to Membership categories:

In favour	97
Against	6

Use of *MBHS* and *HonMBHS*:

In favour	56
Against	54

The changes to the categories of membership were therefore accepted and will be incorporated into the Statutes. However, whilst a narrow majority were in favour of adopting the use of *MBHS* and *HonMBHS*, this change *cannot* be accepted according to the rules for voting enshrined in BHS Statute No 11 which states "Changes in the Statues shall be made only with the approval of three-fifths of those voting in a postal ballot".

Honorary Membership: Dr J S G McCulloch

The President reported that the BHS Main Committee had unanimously elected Dr J S G McCulloch as an Honorary Member for his role in forming the Society and supporting it through its early years whilst Director of the Institute of Hydrology.

Dr McCulloch was delighted to accept Honorary Membership of the BHS and thanked the Society for the honour it had bestowed upon him. He delivered a short address, the text of which appears in *Circulation* (page 10).

Changes to Membership of the BHS Main Committee 1991/92

The Main Committee for 1991/92 had been published in *Circulation 32* in November 1991. Any amendments will appear in *Circulation*.

Investiture of New President by Past President

The President, Allan Lambert, recalled how much he had enjoyed the two years of his presidency. During that time he had had a great deal of help from many people. In particular he thanked Peter Bacos of the Institute of Civil Engineers, members of the Main Committee, the past presidents for their wise advice and his own employer Welsh Water Ltd for allowing him the time to be president. He recalled that the post of president-elect had been introduced, and his successor, Dr Mike Lowing has been elected to fill this post and had therefore served on the Main Committee for the last year. At this point Mr Lambert handed over the Chair to Dr Lowing who became the new President of the BHS.

Address by New President

Dr Lowing addressed the meeting. He felt the Society was on the right tracks and he hoped to keep it there. He felt that the BHS had a really good committee, and that there was a real challenge to follow the achievements of the first eight years of the BHS.

The twin props of the Society, namely the Institute of Civil Engineers and the Institute of Hydrology continued to work well for hydrology keeping the balance right between scientific and applications interest. Allan Lambert had been a thoroughly

good president who had lobbied hard for support from the NRA and the water plcs. There were so many ways he had contributed to the Society and he would be a hard act to follow.

Dr Lowing ended his address with an appeal, pointing out that membership of the BHS was really amazing value. On the future of the BHS, he felt that he could do more. The returned questionnaires from the membership were still being analysed: 358 returns had been made out of a possible 650. He felt that the Society was an independent voice on environmental matters, and would therefore have an important role to play in the future. Indeed, as BHS president, Allan Lambert had recently expressed views to the Energy Minister, Colin Moynihan, on tariffs for hydropower generation (*see page 1*). The future certainly offered much for the BHS.

Independent Environment Agency Proposals

Frank Law of the Institute of Hydrology summarized the current status on the Government's proposal for a new independent Environment Agency. Four options had been put forward, and the Government sought advice on which option was preferred by 31 January 1992. To provide a consolidated response from the BHS Mr Law had prepared a proforma listing the options and seeking the views of the membership. Returns were to be made to the BHS c/o the Institute of Hydrology by 5 January 1992. Mr Law stressed the importance of this opportunity for the membership to let the Government know their collective feelings on this important matter.

Professor Peter Wolf pointed out that the Institute of Civil Engineers were organising a conference in February 1992 on the need for an Environmental Protection Agency.

Any Other Business

No items had been raised in writing, but the President announced that he would accept any other business from the floor. There being no other items, the meeting was closed.

C G Collier
Honorary Secretary

Britain in Hydrology

Jim McCulloch's address to the 8th AGM of BHS

In savouring an occasion such as this, one may perhaps be forgiven for being somewhat philosophical — natural philosophical, no less.

The ancient Greeks' fantastic theories about air, water, earth and fire eventually gave way to hydrological observation and experimentation. The most notable British contributions to hydrology as a science, have been in the study of physical processes and instrumentation. Many names might be mentioned but Halley and Dalton are particularly associated with evaporation and Wren and Hooke with rainfall measurement.

Progress, in these early days, was generally reported to the Royal Society (in the absence of the *Journal of Hydrology* or the *Hydrological Sciences Journal*!) Recently, the US National Research Council, in a publication entitled "Opportunities in the Hydrologic Sciences", included some 20 brief biographies of eminent hydrologists. Inevitably, in a purely US publication, American hydrologists predominated; the two Britons included were Penmen, whose equation for estimating potential evaporation is perhaps the most significant recent contribution to the science of hydrology, *although he laid no claim to be a hydrologist*, and Hurst, whose lifetime study of the hydrology of the Nile will be known to you all.

Despite the relevance and importance of hydrology as the basis of much engineering design and of much geographical synthesis, no hydrological profession or even organisation existed until the 20th century. The International Association of Scientific Hydrology was so named to distinguish *scientific* hydrologists from water diviners.

Indeed, when I took up my duties at the Hydraulics Research Station at Wallingford in 1964, the only regular meeting place for hydrological discussion in Britain was a hydrological group, dominated by engineers, held at the Institution of Civil Engineers (Civils). Of course, physicists and meteorologists meet at the Royal Meteorological Society, geographers at the Institute of British Geographers and hydrogeologists at the Geological Society; however there was no common ground for all to meet as hydrologists, irrespective of initial discipline.

In the hope of resolving this problem, there were discussions about hydrology being accepted into the family of engineering societies, under the aegis of the Civils: the statutes of the British Tunnelling Society were offered as a practical guide. However, this was never followed up. If hydrology were truly a science, rather than an engineering technology, it had to look to the Royal Society rather than to the Institution of Civil Engineers. Sadly, within the Royal Society, the status of hydrology was only that of a sub-committee until the UK IUGG sub-committee was merged with the UK Inter-Departmental Committee for International Hydrology, when full committee status was awarded: then, very shortly afterwards, all the subject committees were abolished.

However, hydrology needs contributions from many scientific disciplines. It has not been at all well served by the artificial barriers which divide academia during this century. While hydrology's principal customer is the engineer, the various sciences incorporated within hydrology extend far beyond engineering. So it was a matter of great pride and satisfaction to me when, under the joint aegis of the Royal Society and the Civils, the British Hydrological Society (BHS) came into being as a learned society in its own right.

Irrespective of their wide variety of previous professional training, all hydrologists are now able to meet on an equal basis. Indeed, when the Royal Society abolished its subject committees, hydrology, represented by the BHS, has proved well able to stand alone. Latterly, the association between the British Hydrological Society and the European Geophysical Society demonstrates a willingness to contribute fully to European scientific endeavours and the adoption of the *Journal of Hydrology* as the house journal for the EGS hydrological sciences section should ensure that British hydrological research papers have ready access to a major international journal.

Over the years, crises of public confidence in environmental matters have stimulated, or discouraged, advances in the hydrological sciences. Twenty years ago, a new ice age was thought to be approaching and the Club of Rome caused equally great concern with their *"Limits to Growth"* publication. In the UK there were many fatalities through river flooding; hence funding was made available for the UK Flood Studies Report. Subsequently, a 1-in-200 year drought in 1975 caused inconvenience but no fatalities; thereafter, investment in water resources research was cut!

All such national and international panics are now subsumed in the present concern about global warming. Such crises may lead to improvements in measurement techniques and networks. However, under no circumstances should they be used as a form of scientific blackmail, to compel governments to spend more and more on collecting data for data's sake: there is

danger of a backlash of public opinion and a growing public scepticism which is harmful to science in the long run. The cost of ever-increasing networks coupled with greater frequency of observation from improved, automated instrumentation may well prove prohibitive. Cost and benefit must be balanced.

In many developing countries, the principal aim of water resources studies in the past has been Water Master Plans, almost invariably comprehensively (and expensively) prepared by expatriate teams and equally invariably destined to remain for ever on the shelf because of their inherent inflexibility. There is a need to communicate priorities to decision makers, to involve nationals in the solution of their own problems and to take into account the managerial and economic consequences.

There is growing international awareness that greater consideration must be given to the economic and social implications of water resources schemes. This leads to the requirement for hydrologists to think more as economists in specifying programmes of measurements. The marginal cost of each percentage point in the quest for greater precision may far outweigh the benefit. On the other hand, the economist's emphasis on short-term expediency versus long-term planning must be restrained: the maximum time span for an economist is often less than ten years, as compared with the 40-50 year plan of a water engineer.

For the future, hydrologists face a challenge to become more globally-oriented. This ambition should not be used as an excuse for short-cutting in scientific rigour. Detailed investigations of hydrological systems in limited catchment areas and of hydrological processes remain a prerequisite for wider extrapolation and conclusions.

Similar political demands for quick scientific answers have been made in the past. The Institute of Hydrology was originally established to resolve a pressing political problem of the comparative water use of forested versus grassed catchments. To extrapolate the results to different environments, it was essential to convince the paymasters of the need to investigate the physical processes underlying such hydrological systems studies. Such a considered approach has paid off. At IH, great advances have been made in mathematical modelling and in other areas of hydrology. But the process studies and instrumentation development undertaken by the Institute over the years are at the forefront of the hydrological sciences to-day.

As small-scale hydrological modelling gives way to regional and global modelling, so the assumptions underlying hydrological statistics must be reviewed. Any trend in global warming — as yet unproven — may invalidate the interpretation of projections from the 30 to 50 years of record on which much hydrological credibility is based. In East Africa and more recently in China, apparent regional discontinuities in the hydrological responses to precipitation must be investigated, taking into account possible changes in the underlying physical processes.

The growth in world population with its inexorable demand for water enhances the importance of the role of the hydrologist. There are those who postulate exponential growth rates in population and even more rapid increases in demand for water, so that countries presently adequately supplied with water will soon have a water crisis.

Despite 40 years of work in amassing hydrological data from all the countries of the world (encouraged by the International Hydrological Decade and the subsequent International and Operational Hydrological Programmes), there are still substantial areas of the earth's surface with few if any observations — or indeed people to make them! There are tremendous opportunities for the younger generation of hydrologists to build, effectively, on the work of the pioneers. armed with remote sensing and information technology, they must seek to develop a more sustainable relationship between human and water resources. Although potable water is far from being a free good, the good news — above all else — is that water **is** a renewable resource!

STOP PRESS

At the close of our straw poll of members' views on the Government's options for an Environmental Agency for England and Wales, the following statistics emerged as a clear-cut result. 124 members voted, just over 20% of those on our latest list:

	First option	*Second option*	*Third option*	*Fourth option*
YES	19%	15%	58%	8%
NO	11%	14%	10%	65%

Thus members clearly favour the all-comprehensive EA that would unite NRA and HMIP. An even bigger majority of us are against a new little agency limited only to environmental policing.

Natural Environment Trust

The Natural Environment Trust (NET) is a newly-registered independent charity. Its aims are the advancement of scientific education through communication between scientists and the public. This will be specifically by way of long-term land-use research into the effects of human activity on soil and vegetation. (Long-term is regarded as *circa* 100 years.)

The intention is to set up inter-disciplinary field experiments under three main themes to provide a context for related specialist research. Water, whether in its gaseous, liquid or solid form, plays a integral role in land-use and so there will be a hydrological aspect to the aspect to the research.

The three main themes for the field experiments will be:

- alternating ground cover land-use,
- building-related land-use,
- continuous ground cover land-use.

The experiments will look at the effects on soil and vegetation. Sites on four different soils with a hydrological history (borehole and flooding) are being sought.

In-depth desk studies will be done in order to set up the experiments in such a way as to get the maximum scientific information out of them. Advice from hydrologists and people working in related fields will be of value in achieving this. Evaporation, evapotranspiration, infiltration, and 3-dimensional water movement through the soil and adjacent bedrock research is relevant. Experiments will be replicated on four different soil types, and there will be one or more lysimeters.

There will be an indoor display showing soil and vegetation development since the last ice age and the human effect on that development. Explanations will be in both plain and scientific English. Variation in the hydrological and climatic conditions during this 10,000-year period has played an important role in the changes. The assistance of BHS

members would be appreciated concerning the hydrological side of these changes.

Comments or suggestions will be greatly appreciated from anyone who feels that some aspect of their work should be taken into account, or who has relevant experience. An advisory team is being set up by the Trustees. NET will have a small, qualified scientific staff to run the experiments.

Fundraising is now in progress. The intention is that the NET should be financially sound right from the start. This will guarantee proper planning and maintenance of the experiments through time and help to maintain the Trust's independence.

For further information contact:
Elizabeth Douglas,
Natural Environment Trust,
38 Brampton Tower, Bassett Avenue,
Southampton, SO1 7FB.

Committee News

Dr Graham Herbertson remains the Secretary of the Scottish Hydrological Group, not Dr David Gilvear as stated in *Circulation 31*.

The Pennines Hydrological Group is now represented on the Main Committee by **Dr Susan Walker**, and the Midlands Hydrological Group by **Paul Webster** as stated on page 14.

GEWEX

The Global Energy and Water Cycle Experiment (GEWEX) is a programme initiated by the World Climate Research Programme (WCRP) to observe, understand and model the hydrological cycle and energy fluxes in the atmosphere, at land surface and in the upper oceans. The goal of the GEWEX programme is to reproduce and predict, by means of suitable models, variations of the global hydrological regime, its impact on atmospheric and surface dynamics, and variations in regional hydrological processes and water resources and their response to changes in the environment, such as the inreases in greenhouse gases.

The Editor has recently received the first issue of *GEWEX News* which details the objectives, programme strategy and implementation plan of GEWEX. For further information or to obtain a copy of the Newsletter (Editor Warren T. Spaeth) please contact the International GEWEX Project Office (Director: Dr Paul D. Try), Suite 203, 409 Third Street SW,
Washington DC 20024, USA.
Telephone: (202) 863-143510012.
Fax: (202) 488 5364.

National Correspondents required for two new IAHS Committees

At the IAHS General Assembly held in Vienna in August 1991, two new Scientific Committees were formed. These are:

- The International Committee on Atmosphere-Soil-Vegetation Relations (ICASVR), and
- The International Committee on Tracers (ICT).

These two new Committees fulfil essentially the same role as the IAHS Commissions and they will each establish a network of National Correspondents. BHS and the UK Committee for IAHS have been asked to nominate appropriate 'experts' as National Correspondents to the two Committees. Anyone interested in serving in this capacity is asked to contact **Professor Des Walling** by **24th February 1992**. His address is: Department of Geography, University of Exeter, Exeter EX4 4RJ.
Tel: 0392 263345; Fax: 0392 263305.

The individuals nominated would also become members of the UK Committee for IAHS.

ICASVR is primarily concerned with the study of water, energy and chemical fluxes within the atmosphere-soil-vegetation system and ICT has an interest in the application of tracers to all aspects of the hydrological cycle (e.g. water, sediment, solutes, etc.).

New Members

We welcome 39 new members to the Society:

Adjei, N.A. ..... Dept. of Civil Engineering, Imperial College, London
Ager, M.C. ..... Swansea, South Wales
Aldam, R.G. ..... Knight, Piesold & Partners, Ashford, Kent
Anderson, J.L. ..... Trochry, Perthshire
Anderton, S.P. ..... Newcastle upon Tyne
Baird, Dr L. ..... Sir William Halcrow & Partners, Swindon
Baker, L.K. ..... Reading, Berkshire
Bassett, T. ..... London
Berry, N.J. ..... Taunton, Somerset
Binnie, C.J.A. ..... W.S. Atkins Water, Epsom, Surrey
Boyce, G.A.J. ..... Exeter, Devon
Cadman, D.E. ..... Sheffield
Chaudery, K.J. ..... London
Cross, R.C. ..... NRA Severn-Trent Region, Solihull
Dobson, C. ..... NRA Severn-Trent Region, Solihull
Eigbe, U. ..... Dept. of Civil Engineering, Imperial College, London
Elliott, J.C. ..... Chertsey, Surrey
Gardiner, A. ..... NRA Wessex Region, Bridgwater, Somerset
Goldenfum, J.A. ..... Dept. of Civil Engineering, Imperial College, London
Green, D.J. ..... Cardiff
Grout, M.W. ..... Dept. of Civil Engineering, University of Birmingham
Hamer, A.R. ..... Solihull, West Midlands
Hindley, E.V. ..... Reading, Berkshire
Karle, M.L. ..... Solihull, West Midlands
Kolsky, P.J. ..... London School of Hygiene & Tropical Medicine
MacDowald, T.D. ..... Scottish Office, Environment Dept., Edinburgh
Marriott, R.F. ..... NRA Northumbrian Region, Gosforth
Nutasara, B. ..... Imperial College, London
Osidele, O.O. ..... Dept. of Civil Engineering, Imperial College, London
Rafelt, A. ..... Ottery St Mary, Devon
Rogencamp, G.J. ..... Shrewsbury, Shropshire
Rourke, M.K. ..... London
Sitton, M.H. ..... Yate, Bristol
Smithard, B.G. ..... London
Soulsby, Dr C. ..... NRA Northumbrian Region, Gosforth
Spence, R. ..... Solihull, West Midlands
Symonds, R.D. ..... Bridgwater, Somerset
Taylor, S.F. ..... Bathpool
Tilley, J.A. ..... NRA South West Region, Exeter

River Sedimentation Problems

BHS Southern Section Meeting
Imperial College, London
16th October 1991

The two short presentations given at this meeting of the Southern Section may have collectively gone under the same general title of River Sedimentation Problems but each had a very different problem to address. The first dealt with an attempt to limit the bank erosion association with meanders while the second was concerned with problems of collecting bedload transport data in ephemeral desert streams.

The meeting was chaired by **Keith Richards** (Cambridge University) who firstly introduced **Dr Richard Hey** of the University of East Anglia whose talk was entitled "Ruling the bends by bending the rules — erosion control at unconfined meanders".

Outer bank retreat of up to 2-3m per annum was identified as a widespread problem at river meander bends, while attempts to prevent such incision were seen to be environmentally rather unfriendly. Methods of bank protection illustrated ranged from the common use of riprapment to a rather more unorthodox approach involving Volkswagen Beetles! Dr Hey put forward the proposal that if the cause of the problem (namely the pattern of flow associated with meanders) was considered, the erosion could theoretically be reduced or stopped without unsightly physical protection of the banks themselves. By reference to field monitoring a secondary flow cell was demonstrated to develop at the apex of meander bends. This cell directed flow towards the base of the outer bank resulting in undercutting and cantilever collapse. The theory behind the proposed erosion control was to suppress the secondary cell development with mid-channel hydrofoil veins positioned to cause the erosive downwelling to occur away from the bank.

The first stage of the work was laboratory-based and involved the use of a meandering flume tank. In this test environment it was found that model veins generated lift forces equal and opposite to the secondary flow. Within the simulation the outer apex of the experimental bend became a zone of deposition while the inner point bar was eroded.

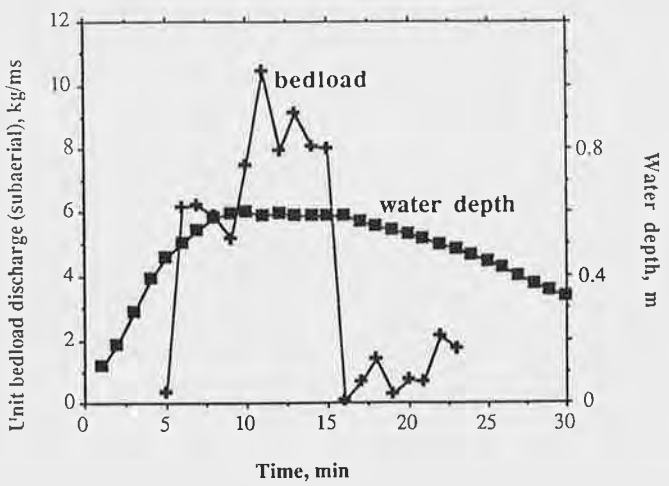
The presentation then turned to the test field site at Loughton, on the River Roding, where a programme of channel straightening had led to bank erosion problems at downstream meanders. The process of vein emplacement was described and illustrated, the veins used in the river were 3m long and 1m high, each made up of 5 modules of 20cm. Emplacement involved driving a pile into the river bed and attaching one end of a vein over it, then orientating the vein correctly before securing it with a second pile. The veins were thought unlikely to become exposed above the water thereby reducing any environmental impact of the approach. In total ten veins were fixed in place on a single meander of the Roding, with a double row pattern adopted where bank erosion was greatest.

Surveying after emplacement showed that although there had been some retreat of the bank top to an angle of repose the outer part of the meander apex had, as modelled, become a site of deposition, while a lip on the bar had been formed by erosion. In the long term it was assumed that the veins themselves would become buried, causing outer bank scouring to recommence. In time this would reexpose the veins making them effective once again. Long-term investigation at the site was however unexpectedly hampered by increased vegetation colonisation of the point bar preventing its further erosion.

During the question session immediately following Dr Hey's presentation the audience were brought up to date with developments on the Roding by **Andrew Brook** of NRA Thames Region who explained that banks at the site had since been eroded by frost action. Attention then turned to the meanders downstream of the test site where it was reported that banks had retreated to such an extend that they required extra protection. It was asked whether the vein structures were though to have increased erosion downstream. The reply was that the effects of vein flow modification were expected to disappear between bends in a similar fashion to natural secondary flow. Further questioning concerned the mathematical criteria used to position the veins, and their cost.

After another brief introduction by Keith Richards, **Dr Iain Reid** of Birkbeck College London began his half of the session which was entitled "All or nothing - bedload monitoring of arid zone flash floods". The presentation was co-authored by **Dr Jonathan Laronne** of Ben Gurion University, Beer Sheva, Israel; unfortunately Dr Laronne had left Britain a few hours before the meeting.

This second case-study certainly represented a contrast in environment to the River Roding. The attention of the audience was now focused towards desert rivers with ephemeral flow regimes. Accurate bedload monitoring was difficult enough in temperate



Automatic record of bedload sediment flux during flash flood at the installation on the Nahal Yatir, Negev Desert, run by Ben Gurion University and Birkbeck College

zones where conditions are relatively co-operative: in arid lands problems are compounded by the unpredictability of flow because of its flashy nature and the huge discharges involved.

It was described how the authors attempted to record bedload transport during flood events using a bedload monitoring device of the Birkbeck automatic pit sampler design developed by Reid and his co-workers at Turkey Brook. This device traps sediment in transport as it falls through slots in the bed into a box in the pit below. A water-filled pressure pillow at the base of the pit provides a continuous measure of the weight of sediment collected. As well as the trap, an installation was constructed at the experimental site, to the north of Beer Sheva on the Nahal Yatir, which allowed hydrological measurements to be taken and featured a bridge from which metering could be carried out.

During four flood events early in 1991 the bedload trap filled to capacity in about twenty minutes, in each case before transport had actually ceased. However, it was clear from the results at what point during an event the trap became full, and the material collected before this time did represent the first ever continuous record of bedload transport data collected during an ephemeral flash flood.

Although the work is still in the analysis phase some initial results were presented. For instance the greatest unit bedload discharges were recorded by the Thalweg trap section in the centre of the stream, illustrating the importance of wall drag at the side of the channel. Typical unit bedload transport rates were calculated as being 6 kg, which is exceptionally high, about twice the maximum unit bedload discharge fluctuates over regular half-minute intervals. These temporal fluctuations are to become a focus of attention in the further analysis of results because they seem to represent the bedload pulsing phenomena widely observed in other environments. At a larger scale each of the flood events showed an initial rise in bedload transport accompanying the flood bore followed by a small decline before rising to a maximum. The traps then tended to fill as the following recession phase progressed.

The presentation ended on a downbeat note when it was reported, and vividly illustrated, that the fourth of the flood events recorded had destroyed the installation, cutting very short the proposed ten years of study.

The question session which followed considered the trapping efficiency of the system before it filled, which was reported as being very high, and also the potential problems of bed scour at the trap site, and site specificity. Finally the discussion briefly touched upon alternative methods of bedload transport monitoring including the use of radio-tagged tracer stones.

As the session drew to a close Dr Richards led the audience in thanking the speakers and then suggested that the two projects described were not altogether unusual in being upset by unexpected developments. He briefly described the project of one of his research students involving the monitoring of a British river which went on to show no sign of activity for three years, an indication as to why "predictable" is not an adjective commonly used to describe programmes of fluvial research!

Ian Drew
Kingston Polytechnic

E-mail

Unfortunately, space limitations prevent the inclusion of E-mail addresses in the forthcoming BHS Membership Directory. A separate list of E-mail addresses will be circulated if enough members register an interest.

David Boorman at the Institute of Hydrology will collate the register: he can be contacted on

DBB@UK.AC.NERC-Wallingford.IBMA

If enough BHS members are interested in this modern form of communication, BHS will consider other high-tech methods of information dissemination, such as bulletin boards.

News from Members

Members on the move

Paul Webster has left Mott MacDonald to take up a lectureship in surface water hydrology at Birmingham University. He hopes to begin a research programme on the subject of hydrological design with inadequate data, prompted by methodological weaknesses discovered during his work overseas.

Paul is a welcome addition to the BHS Midlands Section and he has become its new representative on the Main Committee.

Tom Brabben from Hydraulics Research has been seconded to the Agriculture Department of the World Bank in Washington DC for two years. Supported financially by the Overseas Development Administration, he is one of three Theme Managers on the International Programme for Technology Research on Irrigation and Drainage (IPTRID). His specialisation is "Improving Technology for Maintenance".

Tom will continue to travel widely, mainly to Egypt, Pakistan and Mexico. He will be pleased to meet members who are visiting Washington: his telephone number at the World Bank is +1 202 473 8962.

We have just heard from **Mike Hall** that he has left his post of Professor and Head of the School of Civil Engineering at Middlesex Polytechnic to take up the appointment of Professor of Hydrology at the International Institute of Hydraulic and Environmental Engineering (IHE) at Delft in the Netherlands. Mike says that having been a Visiting Faculty Member there for some 22 years, the change is perhaps not as drastic as might be imagined.

As you will all know from reading the 'Classified Ads' in past issues of *Circulation*, IHE runs a well-established International Course for Hydrologists, which recently celebrated its 25th anniversary. Selected candidates from this 11-month Diploma course have the opportunity to continue for another 6-8 months on an individual project for an MSc and there is also a growing PhD programme at the Institute. All of this means that Mike hopes to be able to devote more time to hydrology than his previous appointment allowed.

Hydrology Chair & Horton Award

Keith Beven has been awarded a personal Chair in Hydrology and Fluid Dynamics at Lancaster University. Keith has been at Lancaster since 1985, and a Reader since 1987. He has been head of the Hydrology and Fluid Dynamics Group within the Centre for Research for Environmental Systems since the Centre was formed in 1987.

The Group currently comprises 28 academic and research staff and graduate students, with active research interests in the surface and subsurface flow, sediment transport and pollutant dispersion processes, radar rainfall estimation, land surface/atmospheric interactions, model calibration and uncertainty estimation. Keith has a BSc in Geography from Bristol University, a PhD from the University of East Anglia and previously worked at the University of Leeds, Institute of Hydrology (twice!) and the University of Virginia.

He is also the 1991 recipient of the American Geophysical Union *Horton Award*, which was presented to him at the AGU Hydrology Section meeting in San Francisco in December. Keith is the 49th recipient of the Horton award and

the first European since **Jim Dooge** in 1960. The citation reads: "for fundamental contributions to the understanding and prediction of runoff generation, particularly the role of topography and soil structure, in natural catchments".

Obituary:

Percy Gordon Spencer

Members will be sad to learn of the recent death of **Gordon Spencer**. A graduate of Sheffield University, Gordon began his career in the water industry with the Derwent Valley Water Board. After service with the Royal Marine Engineers, he worked for waterworks companies in Oxford, Birkenhead and South Essex, becoming Director and General Manager of the Essex Water Company, where he helped to reduce the unit cost of water by almost one-third.

Gordon Spencer was active for many years in the Water Companies' Association; he was also a member of council of the Water Research Centre and of the British Hydromechanics Research Association. In his retirement Gordon Spencer took to farming in Norfolk, where he died on 15th October 1991 at the age of 71. He is survived by his widow, Peggy, and by two sons.

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FORTHCOMING EVENTS

Postgraduates live!

2nd Postgraduate Symposium, Edinburgh, 10-12 April '92

The inter-disciplinary approach in practical applications of hydrology

Many thanks to those who responded to my questionnaire seeking expressions of interest in the postgraduate symposium. I am now very pleased to report that I received an enthusiastic response from all around the country and that the symposium will therefore go ahead. Timed for 10-12 April, it will follow on from the European Geophysical Society XVII General Assembly.The symposium will be held in the informal atmosphere of an assigned room in the Edinburgh University Students' Union, and we expect a lively and enthusiastic occasion.

The aim of the symposium is to give postgraduates (current and recent) the chance to present their work and discuss ideas and difficulties within their peer group. Any aspect of hydrology can be covered, but there will be a general theme of *The inter-disciplinary approach in practical applications of hydrology* to provide a focus. Eminent hydrologists are being asked to chair the presentations. Coupling the symposium to the EGS General Assembly also provides an excellent opportunity for students to attend both meetings and mingle with a wide community of scientists.

Further details and a registration form are enclosed with this issue of *Circulation*, the form to be returned as soon as possible (certainly by **6 March**). Supervisors are especially asked to encourage their postgraduate students, including those who have just completed their work, to participate in what can be expected to be an enjoyable and stimulating weekend.

James Bathurst

Meetings

Half-day Meeting
CONSULTING OVERSEAS — PRACTICALITIES, PROBLEMS AND PERILS
3 June 1992
Institution of Civil Engineers

Four invited papers will be presented on various aspects of consulting activities overseas by members of two of the largest UK consultants, Institute of Hydrology and a freelance consultant. The four papers promise to provide sufficient controversy for a lively discussion at the end of the afternoon. Participation is welcomed from hydrologists directly involved in overseas work and also those in the industry and academia. Papers vary in content from "Project management in development " by Dr Ron Manley, to "Never let the facts confuse a good model: ignore the data!" by Dr Peter Adamson. Not to be missed!
Further details from Dr Richard Harpin (*Tel:* 0734 812479 *Fax:* 0734 812089)

British Dam Society, BHS, SHG and IWEM joint conference on WATER RESOURCES AND RESERVOIR ENGINEERING
24-27 June 1992
Stirling

This conference will explore current issues and recent developments in reservoir planning, operation and environmental aspects, design and construction, monitoring and maintenance.

There will be sessions on the Flood Studies Review, the DoE reservoir research programme and the BRE dams database, as well as a visit to Lednock Dam. The Geoffrey Binnie Lecture on 26 June will be delivered by Dr Pircher, President of ICOLD.

Application for registration (£240, including accommodation and a pre-published volume) should be made by **11 May 1992** to the Secretary, British Dam Society, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA.

Further details from Dr Susan Walker, NRA North West Region, PO Box 12, Knutsford Road, Warrington, WA4 1HG.

CATH ALLEN MEMORIAL MEETING
OF THE CHALLENGER SOCIETY
Physical Mechanisms of Mixing and Transport in the Environment
29 June–1 July 1992
Lancaster

This is planned to be an interdisciplinary meeting, bringing together researchers from different backgrounds to exchange experiences, theories and techniques for understanding and modelling physical mechanisms of pollutant transport. It is hoped that marine, coastal, riverine, lacustrine, atmospheric and subsurface environments will be represented, and studies of mixing and transport of gases, solutes, particulates and other characteristics.

The meeting is intended to reflect the research interests of Cath Allen, who tragically died of cancer last year.

Oral and poster papers are invited. Abstracts should be sent immediately to the convenor, **Dr Keith Beven**, Centre for Research on Environmental Systems, Lancaster University, LA1 4YQ.
Tel: 0524 65201, Fax: 0524 843854.

BHR Group
3rd International Conference
FLOODS & FLOOD MANAGEMENT
24-26 November 1992
Florence, Italy

Subjects to be covered are: Basin management, planning & flood defence systems; Hydrologic and hydraulic modelling; Urban drainage; Control structures & conveyances; Geomorphology & sediment; Risk, hazard & damage assessment; Environment & amenity impacts; Maintenance & standards of service.

Authors are invited to submit title and abstract of papers by **13 March 1992** to the Conference Organiser, Floods, BHR Group Ltd, Cranfield, Bedford, MK43 0AJ (Tel: 0234 750422).

UNESCO
2nd International Conference on FRIEND
11-15 October 1993
Braunschweig, Germany

The conference themes are:
- FRIEND data base, its extension, future use and development
- Low flows, their parameterization, regional analysis and affecting factors
- Characterization of large scale variations in river flow behaviour
- Techniques for extreme rainfall and runoff estimation
- Catchment processes of streamflow generation in small basins
- Hydrological regionalization
- Use and efficiency of hydrological networks for research purposes

Further details from:
Prof Dr A Herrmann, FRIEND 1993,
Institut für Geographie und Geoökologie
Technische Universität,
Langer Kamp 19c
D-3300 Braunschweig
Federal Republic of Germany

Copy Deadline for Issue No. 34
3rd April 1992

*** Articles submitted as word processed files on disk are our favourites.**

Diary

19th February 1992
Royal Meteorological Society
"Terrestrial processes in climate models"
Venue: Imperial College, Prince Consort Road, London SW7.
Time: 2.00 p.m.
Organiser: Dr John Stewart, Institute of Hydrology, Wallingford (0491) 38800.

4th March 1992
"Radar and flood forecasting using radar measurements of rainfall"
Report of results of joint NRA (Thames & North West) and Met. Office project.
Venue: Institution of Civil Engineers
Contact: Chris Collier, 0344 856911.

13th March 1992
Scottish Hydrological Group
"Wetland hydrodynamics and hydrological vulnerability assessment"
Dr David Gilvear, Stirling University
Venue: No. 2 Lecture theatre, McCance Building, Strathclyde University.
Time: 6.30 p.m. (tea at 6.00 p.m.)

25th March 1992
BHS National Meeting
"Hydrology, urban development and water quality"
Venue: Institution of Civil Engineers
Contact: Dr Howard Wheater, Dept. of Civil Engineering, Imperial College.

31st March 1992
Scottish Hydrological Group
Joint meeting with BHS, IWEM and SHSG: "Floods in Scotland"
Venue: Perth. Further details later.

1st April 1992
Southern Section AGM
"Restoring over-abstracted catchments"
Institute of Hydrology, Wallingford.
Contact: Dr Howard Wheater, Dept. of Civil Engineering, Imperial College.

10th-12th April 1992
Second Postgraduate Hydrology Symposium, Edinburgh (see notice).

3rd June 1992
BHS National Meeting
"Consulting overseas" (see notice).

24th-27th June 1992
BHS/Scottish Hydrological Group/ British Dam Society/IWEM conference "Water resources and reservoir engineering." Stirling. (see notice).

Circulation is the quarterly newsletter of the British Hydrological Society. It is issued free to members, but is also available on an annual subscription of £18. All enquiries concerning membership should be made to Peter Bacos, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA. Telephone 071 222 7722. Please address all other correspondence to the Editor, Celia Kirby, Institute of Hydrology, Wallingford, OX10 8BB. Telephone: 0491 38800 extension 2360. Fax: 0491 32256.