THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

Circulation

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A consultant in Turkey



The call came one Thursday morning. How would I like to get away from a British November and spend a week or so looking around a beach and lake in south-west Turkey? It was a tough decision and I agonised about my other commitments but, about seven seconds later, I agreed to go. A couple of weeks later I found myself in the kind of idyllic surroundings which you see in holiday brochures but you suspect do not really exist, certainly not on the Mediterranean.

The client was the International Union for the Conservation of Nature (IUCN) - a sort of official watchdog for the world's wildlife - in Geneva. It shares a building, and many areas of interest, with the WWF. I had **Ted Hollis** to thank for giving them my name but, when he discovers how much I enjoyed it, he may regret having had to pass the job on!

The beach in question was on our television screens about a year ago when proposals to build a huge hotel complex right on the sand at one end of it were withdrawn in the face of worldwide condemnation. Why? Because it is also one of the main nesting sites for the Loggerhead and Green turtles, and turtles and tourists don't mix too well. The existing control is by a line of stakes below which it is forbidden to dig or use beach umbrellas! Also, nobody is allowed on the beach after 8.0 pm. How the turtles know to restrict their choice of nest hole to the sea side of the stakes was a bit of a puzzle. Anyway, it seems to work and with the cancellation of the hotel and the creation of a 'Specially Protected Area' (SPA) to cover the whole area of the beach, the 65 km² of lake and wetlands behind, and a sizeable chunk of land around the edge of the lake, you would think the turtles would be happy. And so they might well be - but they don't know about Planning.

Planning is the process by which a large number of quite well paid citizens meet (and meet again) to discuss how some things can change without other things changing. The planning in this SPA was essentially about the numbers of residents and tourists who might be



catered for in the future, not only on the beach but on the lake and wetlands, in the local towns and archaelogical sites, in the forests and on the hills. It was also about what controls might be necessary to limit their activities in space and time.

I discovered all this on day one, but I was no nearer understanding where hydrology came in. Except of course, as every hydrologist knows, it comes into everything. The sewage works, the water supply, the sediment in the lake, the salinity, the fisheries - the whole ecosystem is actually driven by the hydrology. Upset the balance of the lake chemistry by changing agricultural practice on the catchment and the effects could be felt by the beds of sea grass on which the turtles feed. Affect the stability of the beach by building a toilet block on its spit and you could change the potential for interchange between the sea and the lake. So - what to do? There were no data of any kind. There were no maps. There were no sewage works yet either. Never mind, my kindly IUCN 'control' had said back in Geneva, just look around for us and have a good time.

So here we were, three of us: a retired hippy now teaching geography in Canada (the expert on tourism), a globe-trotting ecological management specialist from Scotland and me. We hired a little Suzuki jeep and nosed about the highways and byways to 'get to know the area', cameras clicking like the tourists whose likely behaviour we were studying in their total absence, and - in my case - binoculars at the ready. (Did I tell you that the lake and wetlands are notable bird-watching haunts?) We explored the hills and forests of pine and 'amber' trees; we investigated the ancient city overlooking the estuary; we walked the length of the beach; we went into the catchment and looked at the irrigation and orchard practices; we went on a boat trip from the lake, through the wetlands, to the beach: we had a hell of a tough time.

In the end, a friendly lady from the SPA authority in Ankara turned up. She not only gave us some more meaty facts but, with her excellent English, also enabled us to converse with the locals rather more meaningfully than hitherto. She also produced (later) some old data on lake levels, rainfall, and river inflows which allowed some pretty basic water balance calculations. As we had been led to believe that the lake was 8 m above the level of the sea, it gave me considerable pleasure to show that there was a net inflow from the sea to the lake for two or three months in an average summer and hence to disprove that unreliable old saying in hydrology that water always flows downhill. However, just in case the old wisdom is correct, I recommended a survey!

Please don't tell anyone else about this place. It was so beautiful that it was hard to believe that we were being paid to be there! But don't tell about that either: I want to be asked again. Perhaps next time I will get to see one of those turtles.

Mike Lowing

AGM - Minutes

BHS 7th Annual General Meeting
University Centre, University of Birmingham
10 December 1990

Present:

Allan Lambert, President,
Dr Susan Walker, Hon. Treasurer,
42 members.

President's introduction

The President thanked all those members who had managed to attend the AGM in spite of the severe weather. Travel had been made very difficult by the heavy snowfall over the previous weekend. Apologies had been received from Professor G. Petts (Hon. Secretary), Dr P. Walsh, L. Jack and R. Manley [Mr N. Tyler and Professor P. Wolf arrived just as the AGM was finishing, having been delayed by rail problems]. The minutes of the last AGM were distributed. An abbreviated version had been published in *Circulation* No. 25.

The President apologised for not yet having managed to visit the south west and southern sections of the Society. This he hoped to rectify soon. During the last year a strong effort had been put in by all the Main Committee members, and particular thanks were due to Professor Petts, Max Beran and Frank Farquharson, who were leaving the Main Committee, to Peter Bacos and Norman Tyler for their secretarial support and to Celia Kirby for her continued hard work in editing *Circulation.* A third Occasional Paper on quantifying drought return periods was in preparation and advanced orders had already been received.

Minutes of the 6th AGM held at ICE, 4 December 1989

There being no discussion of the minutes of the 6th AGM, Chris Collier proposed that they be accepted and the minutes were duly approved.

Report of the Honorary Secretary

Professor Petts had not been able to attend the AGM and his report was presented by the President. The full report had been published in the November 1990 issue of *Circulation.* The membership of the Society continued to increase, with 589 members on 30 September, and 42 members who had joined since then.

The Main Committee had produced guidelines for the selection of Honorary Members of the BHS which had been approved by the general membership. The Statutes of the Main Committee had been changed to include representation from the regional groups rather than the previous co-option arrangements.

The first Postgraduate Symposium on Hydrology had been successfully organised by Professor Petts and was attended by 35 students. A second symposium was presently being organised by Dr Peter Sims of Polytechnic South West, and had been publicised in *Circulation.* It was hoped that this symposium would be attended by some European students, and some sponsorship had been obtained from IAHS and the European Geophysical Society.

During the year two meetings had been organised jointly with other organisations. A meeting on natural hazard disaster reduction had been organised with the Royal Meteorological Society and held at the Royal Society, London, and a meeting on river flood hydraulics had been organised with Hydraulics Research, Wallingford. Unfortunately the northern field meeting had had to be cancelled due to lack of support. Any ideas for meetings from the membership would be welcomed. Congratulations were offered to the Pennines Hydrological Group on holding their 21st birthday meeting during the year.

The Honorary Secretary thanked Dr Susan Walker, Honorary Treasurer, for all her work on negotiating a route to membership of ICE for BHS members who would not qualify through the normal procedures. So far, at least 35 members of the BHS had expressed interest in proceeding with such a membership route.The BHS had formed an international liaison sub-committee and had become associate members of the European Geophysical Society, the next meeting of which was to be held in Edinburgh in April 1992. Work was under way to organise the 3rd National Hydrological Symposium which would be held in Southampton in September 1991.

The report of the Honorary Secretary was approved by those present.

Report of the Honorary Treasurer

Dr Susan Walker, the Honorary Treasurer, apologised for the late distribution of the balance sheet which had been delayed by the late arrival of those travelling from London. [The balance sheet was distributed during the AGM].

For year ending 30th September:

Income:

1990	1989	
£9123	£14,102	(includes £7205 from the 2nd National Symposium)

Expenditure:

1990	1989
£7849	£16,044

Surplus (deficit):

1990	1989
£1274	(£1942)

It had been decided to combine the Membership Directory with the Directory of Hydrology and this was expected to be a significant outgoing during 1991 as a one-off purchase of A4 binders would be necessary. A float of £3793 was available, an increase over the previous year; however Dr Walker did not regard this as a satisfactory cushion against any losses which might be incurred. She noted that the cost of meetings was steadily increasing. This was partly due to the fact that universities were now

charging commercial rates for the hire of their facilities. The Main Committee had therefore decided to introduce minimum charges for national meetings. These charges had been published in *Circulation* and were:

Members	£5
Non Members	£10
Student Members	£0
Student non-members	£5

The BHS had been delighted to received £437 profit from a meeting entitled Hydrology of Landfill Sites, organised some time ago. In spite of this improved financial position of the Society, it was necessary to increase annual subscriptions by £2 for full member and by £1 for student members. These increases would cover the costs associated with the new directory. The 3rd National Symposium at Southampton in September 1991 would be sponsored for one day by the National Rivers Authority.

Finally Dr Walker expressed her thanks for their help to the financial staff of the ICE, Mary McBride and Marianne Foster. Dr Mike Lowing proposed that the Honorary Treasurer's report should be accepted. This was seconded and carried unanimously.

Officers and elected members

It had been decided by the Main Committee to bring forward the election of the new President in order that the Society would have a President Elect for a one-year period. The result of the ballot was announced. Dr Mike Lowing had received the highest number of votes and duly became President-Elect. The President congratulated Dr Lowing and thanked the other Candidates, Roy Wood and Frank Law, for their participation in the election.

The new Honorary Secretary was announced as Chris Collier of the Meteorological Office. The election for the two places on the Main Committee of the Society had resulted in the election of Frank Law (Institute of Hydrology) and a tie for the second place. However, as Chris Collier had become Honorary Secretary a third vacancy had been created. Hence Dr James Bathurst (University of Newcastle Upon Tyne) and Ron Manley (consultant) were duly elected to fill the two remaining vacancies.

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
Hon Secretary

BHS establishes UK Committee for IAHS

The Royal Society has appointed **Professor Des Walling** as the UK National Correspondent to IAHS for the period up to and including the IAHS General Assembly which is to be held in Vienna in August 1991. Professor Walling, who is currently the UK National Representative for the IAHS International Commission on Continental Erosion, succeeds **Dr Jim McCulloch**, who has acted as the UK National Correspondent with distinction over the last eight years. The President of BHS will act as deputy in the absence of the National Correspondent.

Following the winding-up of the Royal Society Hydrology Subcommittee in early 1989, it has been agreed that BHS will be the UK learned society which will articulate the interests of the UK hydrological community in the activities of IAHS and advise the IUGG Representative on the Royal Society International Relations Committee (IRC), currently **Professor Martin Bott** FRS, on IAHS matters. At the appropriate time, BHS will (together with other learned societies representing IUGG interests) be invited to nominate a successor to the IUGG Representative on the IRC. The following additional arrangements have been agreed with the Royal Society:

(i) BHS will establish a UK Committee for IAHS whose membership will include the BHS President, the National Correspondent to IAHS who will chair the Committee, the National Representatives for the IAHS Commissions and Committees who will be appointed by BHS and any UK hydrologists who are officers of IAHS. This committee will be responsible for coordinating the involvement of UK hydrologists in the activities of IAHS, and, from time to time, for advising the Royal Society and the IUGG Representative on the IRC on IAHS matters, including the appointment of future National Correspondents to IAHS and UK nominations for IAHS officers, awards and prizes.

(ii) The Royal Society will call upon the BHS to advise on the utilisation of income from the IAHS Exeter Fund. This fund is administered by the Royal Society and was established to assist research and education for the advancement of hydrological sciences in the UK by:

- provision of travel grants to facilitate attendance at IAHS and related international meetings;
- promoting interest and scholarship in both scientific and applied aspects of hydrology in the UK;
- providing financial assistance in organising international hydrological meetings in the UK.

Traditionally, the income from this fund has been used to assist young scientists to attend the Scientific and General Assemblies of IAHS. The BHS will draw its advice on the use of this fund from the UK Committee for IAHS.

Appointment of UK Representative to the IAHS International Committee on Surface Water (ICSW)

As noted above, the UK Committee for IAHS which has been established by BHS is responsible for links with the International Association of Hydrological Sciences. One of its roles is to appoint the UK Representatives to the various IAHS Commissions and Committees, who will also serve as members of the UK Committee for IAHS. **Logan Jack** has recently indicated his wish to be replaced as UK Representative to ICSW and a successor is being sought. Anyone wishing to be considered for this position should contact **Professor Des Walling**, the UK National Correspondent for IAHS, by **7 March** at the latest. He can be reached at: Department of Geography, University of Exeter, Amory Building, Rennes Drive, Exeter EX4 4RJ, Tel. 0392 263345. The National Correspondent, assisted by the UK Committee for IAHS, will make the final decision as to who will represent the UK on ICSW.

ICSW is the Commission of IAHS responsible for surface water hydrology. It is involved in the expansion of the scientific basis for utilizing surface water and in the extension of this knowledge to assist the practitioner, especially in developing countries. The Commission cooperates extensively with UNESCO and WMO and has made a substantial contribution to a number of IHP projects. A good example is the World Catalogue of Maximum Floods published by IAHS. It also has a strong interest in hydrometry, regional hydrology research on small basins, the influence of man on the hydrological cycle and the influence of climatic change and climatic variability on the hydrological cycle. The Commission has organised several symposia on these themes in recent years. The UK Representative to ICSW is responsible for promoting contacts between UK hydrologists and the Commission and would be expected, where possible, to attend Commission Assemblies which are held during the IAHS General and Scientific Assemblies.

Birmingham AGM

It has been decided that the registration fee will be refunded to those who had paid in advance but could not attend because of the severe travel disruption caused by the weather. Anyone requesting a refund should write to Peter Bacos, c/o BHS, ICE, Great George Street, London SW1P 3AA.

Those who were able to fight their way through the snowdrifts will be pleased to hear that the University has reduced their charges for the meeting since they were unable to heat the Avon Room or provide a hot meal at lunchtime because of the power interruption.

Rather than provide a refund to all who attended (and incur the hefty administration cost associated with this), the money will be used to subsidise the cost of the AGM next December.

BHS Main Committee 1990/91

Elected Officers & Members

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Pennines Hydrological Group
Dr John Mawdsley
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Member appointed by the ICE Council
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Member appointed by the Director of the Institute of Hydrology
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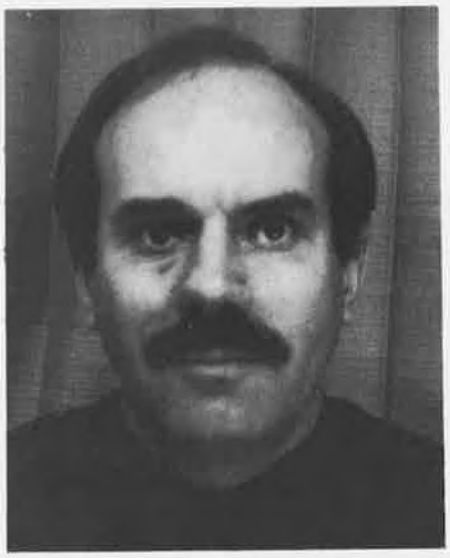
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Tel: 071 839 9838
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Treasurer to the Main Committee:
Miss M McBride
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NEW COMMITTEE MEMBERS

Dr James C. Bathurst
Since 1985 James has been on long-term secondment from the Institute of Hydrology to the NERC Water Resources systems Research Unit, University of Newcastle upon Tyne. Here he is a programme leader working on physically-based, spatially distributed modelling of water, sediment and radionuclide transport at the catchment scale. Based in particular on the Système Hydrologique Européen (SHE) modelling system, the work has involved a number of international collaborative and technology transfer projects. Within the Unit, James is currently involved in the development of a landslide erosion model and an international EC-supported study of desertification in Mediterranean Europe: here the SHE will simulate the impact of likely changes in climate and land use on basin hydrology and soil erosion. He also has a long-standing interest in the hydraulics and sediment transport of mountain rivers and is never happier than when wielding a Helley-Smith bedload sampler on location! His recent visit to New Zealand to study landslide erosion, supported by a Churchill Fellowship, is described on page 15 of this issue of *Circulation*.





R. E. Manley
For ten years Ron has worked for the Trent River Authority in Nottingham, and its successor the Severn-Trent Water Authority in Birmingham. In 1980 he joined Sir M. MacDonald and Partners (now Mott MacDonald) and with them and the World Meteorological Organization he has since worked in some 25 developing countries. His main long-term overseas tours have been in Libya (1.5 years), Niger (3.5 years) and Indonesia (2.5 years). In the last two of these countries he was Project Manager for two large flow forecasting projects financed by the United Nations. He has continued with his interest in mathematical model development which started with his work on HYSIM while with the Trent River Authority. Ron is also a Director of the non-profit-making UK Council for Computing Development. He is currently working as a freelance consultant in engineering hydrology and computing.

Technician Training

When the Education and Training Subcommittee was set up, it was agreed that, after the problems surrounding the route to chartered status for BHS members had been resolved, the issue of Technician Training would be addressed.

The E & T subcommittee is now wishing to consider Technician Training if it is still perceived that there are problems to be overcome.

Sue Walker, Chairman of the E & T subcommittee, would be pleased to hear from anyone who has any views on the matter. Bearing in mind that many of the people affected could be field staff who may not see *Circulation* directly, Sue would be grateful if you could make a point of passing on the message to anyone who might be interested.

Sue can be contacted at North West Water Ltd., Dawson House, Great Sankey, Warrington WA5 3LW (Tel: 0925 233577).

Modelling the Hydrological effects of Land-use Change in Small Catchments

Mr Ill Son, a Korean, has received his doctorate for a thesis with the above title submitted to the Geography Department at Southampton University.

In essence, 43 previous studies on vegetation and runoff from 65 catchments were concisely tabulated and their relationship between vegetation change and storm runoff was reviewed. A regression analysis interpretation was derived, but this "could not be employed to produce sound estimates of the hydrological consequences of land-use changes".

Instead, HYRROM, one version of the IH conceptual lumped model, was used to optimise data from three Zimbabwean catchments and three in Kenya. The 9-parameter model was then refined into an 11-parameter, 3-storage, 1-input-option version. Model efficiencies exceeded 95% on daily datasets covering about 16 years. Errors in total flow were less than 5% for ten separate periods.

In one Kenyan catchment, a 46% loss of rainforest to tea plantations was shown to decrease water use by 30% and to double the annual peak flows. In another, conversion from clearcut to pine plantation increased water use by 30% and decreased annual peak flows by 30%. In the third Kenyan catchment the flow regime did not change significantly by moving from sporadic to intensive grazing.

Frank Law
IH, Wallingford

Stream Runoff Process Studies

As part of the Unesco IHP IV : Flow Regimes from International Experimental and Network Data (FRIEND) I am coordinating the compilation of an international Catalogue of studies of *Physical processes of streamflow generation in small basins.*

This will cover the countries of northern and western Europe, and it is hoped that the Catalogue will be published as a means of encouraging cooperation between field scientists facing similar problems (e.g. how to sample soil water in a meaningful manner). This will perhaps lead to exchanges of data, and will also provide a basis for hydrological modellers looking for validation data sets.

Anyone interested in contributing should send me the following details of their research catchment(s):

Catchment area, location, vegetation and soils, study period, hydrological parameters measured (and observation interval), the objectives of the study and details of any publications.

Dr Mark Robinson, Institute of Hydrology, Wallingford, Oxon OX10 8BB *(FAX 0491 32256)*

"NRA will be uncomfortable to live with"

. . . warned Lord Crickhowell, speaking at the *Water Privatisation - One Year On* seminar in London last November. The Chairman of the NRA was the opening speaker at the third seminar on water privatisation, organised by ICE and co-sponsored by IWEM and was stressing the seriousness of the job the Authority has taken on as guardians of the water environment.

Attended largely by representatives from consulting engineering firms and the water utilities, Lord Crickhowell certainly gave his audience much to ponder. He began by saying that the setting up of the NRA was good news for the environment, not least because the attendant privatisation meant that the industry now has access to the means for fund-raising not possible before and many essential capital programmes can now take place.

However, Lord Crickhowell warned that the NRA is not satisfied with the existing protection of the environment and will be looking at ways to improve on this.

"Let us be quite clear," he said, "the existing capital programmes will merely meet the needs identified before privatisation and much more needs to be done."

NRA is now beginning to work on the requirements for the new statutory water quality objectives. These will become law in 1992 and are bound to lead to more capital expenditure. The recent Kinnersley Report had given a clear view of environmental targets and had included, among other things, the need to ensure that existing EC standards are met and that 1985 river standards are maintained. It will be for central Government, however, to reach a view about the cost implications of all of this and the timing required before it will be able to set the River Quality Objectives.

One thing is certain, the costs must include provision for damage to the environment from increasing supplies.

"Environmental improvement is an expensive business", said Lord Crickhowell, "and ultimately, the decision about what charges/costs are realistic lies with Parliament."

He went on to remind the audience (not that this particular audience needed any such prompting) that it is not the water industry alone which is responsible for poor quality in rivers. Neither is it just an industrial problem: changes in agricultural practices and land use also contribute, as does the severe damage done by over-abstraction in major catchments.

All this means higher water charges, but before getting too despondent it was worth reminding ourselves that they still compare well with those operating in many other European countries.

BRITISH COUNCIL FUNDS

Hydrologists have been having marked success with the British Council in obtaining travel funds. This has come about because of the initiative of individuals and takes two forms.

The first involves approaching, at any time of year, the British Council office in the country to which you need to go. The Council needs to know of some mutual scientific interest that will be stimulated between bodies in the countries involved: collaboration can be in research, publication, curriculum or staff training, and occasionally presenting a conference paper. From the Institute of Hydrology **Ros Gross** visited Norway and **Ian Littlewood** is going to the Australian National University shortly.

The second method is to respond to a specific British Council scholarships advertisement and face a shortlist interview. By this means **Nick Bonvoisin** and **Andy Bullock** of IH will visit Mongolia early in 1991.

Worldwide British Council addresses are in its annual report, available from 10 Spring Gardens, London SW1A 2BN.

American hydrologist Ray Linsley dies

Ray K. Linsley, an internationally-known hydrologist and expert on water resources, died last November in California, aged 73.

Linsley was emeritus professor of civil engineering at Stanford University, where he had been since 1950; before that he was an engineer for the Tennessee Valley Authority and head hydrologist for the US Weather Bureau in Washington.

Early in his career he was a Fulbright professor at Imperial College, London. He was also active in consultancy to overseas governments and WMO. In the early 1960s Linsley helped to found a programme to expand the education of civil engineers beyond project design into the social, political and economic areas which affect their work.

He advocated water conservation in the USA as long ago as 1955, when the Federal Government was still constructing large reservoirs and irrigation schemes. In 1968, President Johnson appointed him to a national water commission to study ways of fighting water pollution and of ensuring adequate water supplies.

After his early retirement in 1975, he became president of a consulting firm specialising in hydrological modelling.

NEW MEMBERS

We welcome the following members who have recently joined the Society:

Adeloye, A.J.	Imperial College, London
Baird, A.J.	University of Bristol
Bhatia, S.K.	Rajasthan Housing Board, Jaipur, India
Chirwa, A.B.	Ministry of Works, Malawi
Datta, S.	West Bengal Pollution Control Board, India
Davies, A.F.	Water Research Centre
De Troch, Prof. F.P.	State University, Ghent, Belgium
Dick, Dr. T. Milne.	Director, Environment Canada, Saskatoon
Ekanem, A.E.	Cross River State Water Board, Nigeria
Etoina, E.B.	Cross River State Water Board, Nigeria
Fawcett, K.R.	University of Bristol
Ganjigatti, S.B.	Bangalore Water Supply and Sewerage Board, India
Greenhill, R.K.	University of Bristol
Grew, R.	NRA South West Region
Kalluru, P.	Panchayatiraj, Hyderabad, India
Mathur, D.C.	Jaipur, India
Matondo, J.I.	University of Dar es Salaam, Tanzania
Mazyimayi, D.	University of Zimbabwe
McKenna, E.	Robert H. Cuthbertson & Partners, Edinburgh
Meshram, A.Y.	Maharashtra Water Supply and Sewerage Board, India
Mohamad Said, A.R.	Malacca Water Board, Malaysia
Mohanty, P.K.	Housing and Urban Development Dept., Orissa, India
Munugeti, S.N.	Andhra Pradesh State Government Service, India
Muten, T.J.	Newcastle University
Okpo, M.E.	Cross River State Water Board, Nigeria
Papaioannou, A.	Hydrotechnica
Reshi, M.Y.	Jammu and Kashmir, India
Sackey, P.O.	Ghana Water and Sewerage Corporation
Sethuraman, R.R.	Ministry of Urban Development, India
Srinivasa Reddy, B.R.	Karnataka Urban Water Supply & Drainage Board, India
Teketel, M.	Ethiopian Water Works Construction Authority
Thompson, D.B.L.	Ghana Valley Water Company
Ward, Dr W.H.	Consulting engineer
Wilby, R.L.	Nottingham
Wood, G.	North West Water
Yusof, A.T.M.	Water Supplies Branch, Kuala Lumpur, Malaysia
Zunjarwad, G.V.	Maharashtra Water Supply and Sewerage Board, India

1989-90: A PERIOD OF CONTRASTS

BHS National Meeting
10 December 1990

This meeting was held following the AGM, under very difficult circumstances resulting from the heavy snowfalls in the Midlands during the previous weekend. Several amendments to the schedule were made during the course of the day, as speakers appeared, and in all four of the promised seven papers were presented. Around 80 of the 120 people who had booked places eventually arrived. Unfortunately the University was also operating under difficulties. Power reductions meant that we had no heating, and the promised hot lunch also turned into salad. The cheese and wine at the end of the meeting was therefore a welcome morale booster. The hardiest members then stayed on for a meeting of the British Dam Society on the East of Scotland floods of 1989 and 1990.

Phil Turton of the Water Services Association presented the first paper, entitled *1989: A record year for weather records*. He gave a brief overview of 1989 weather, and drew attention to the almost unbroken series of positive temperature anomalies in England since November 1988. Rainfall had been more variable, with very few "average" months. Fortunately the dry winter of 1988 was followed by a very wet spring. In 1989-90, December, January and February were also wet. The 1989 summer mean temperature anomaly was +1.5°C, so this might be a typical summer by around 2030 if we accept the IGPCC scenario with no reduction in emissions.

(A show of hands indicated that between a quarter and one third of the audience believed that climatic change is already occurring. Very few were convinced that it is not; the majority were sitting on the fence.)

Recently there have been indications that politics may be rationalised into policies, and that the DoE has accepted the need for research into the possible effects of altered rainfall patterns. In the water industry a need for new sources would pose problems of land acquisition. There may also be increased potential for demand management. Supply, demand, and the consumer are all closely interlinked. As a result of the publicity given to climatic change, hydrology has a higher profile than for many years.

Lindsay Macmillan from South West Water presented a review of operational aspects of recent droughts in South West England.

South West Water experienced problems in the summers of both 1989 and 1990, due to lack of rainfall, and difficulties in transferring water to where it was required.In 1988 problems were mainly with local distribution, apart from Central Devon where a new reservoir was nearing completion at Roadford. In October 1989 impoundment began, and the reservoir was half full by February 1990. The capital schemes for the transfer of Roadford water were therefore accelerated. This proved very useful in the ensuing drought: Roadford water reached Bude by 31 July 1990 (in 1989 standpipes had been installed but not used). Both summers brought problems in East Devon, where the Axe Reservoir is due for completion in 1995.

In drought management timing of all measures was found to be crucial. River recessions were monitored weekly, then daily as the drought became established. Control curves were used to operate the reservoirs. South West Water have found publicity to be effective in restraining demand. Hosepipe bans are also quick to implement and result in a drop in demand of around 10%. These were in force throughout the South West Water area by the end of June 1989.

In practice, drought orders take a month to set up, so recessions must be monitored with this in mind. Non-essential user bans were also used in 1989, and powers to implement rota cuts and use standpipes were granted on 31 August 1989 by the DoE, but were never used. Considerably fewer hosepipe bans were issued in 1990, and with Roadford in full operation it is hoped to eliminate them completely.

A questioner asked whether, in the light of possible climatic change, South West Water felt the need to review their design droughts. Lindsay pointed out that the reservoirs were designed against the 1 in 50 year event, and it might be easier to control demand than to change design standards.

Allan Lambert drew attention to the dangers of assuming that a design drought ends by a certain date. If it does not, the yield calculation is flawed. He advocated a switch to yield calculation methods based firmly on operational practice, even if the resulting values were reduced.

Terry Widnall of NRA Welsh Region described the Towyn sea floods of 1990. He outlined the historical development of this low-lying area of the North Wales coast, and highlighted how the responsibility for sea defence and coast protection had become split between British Rail and underfunded local councils, with the NRA now responsible for sea drainage.

On 26 February 1990 a vigorous but slow-moving depression over the UK caused north-westerly gales and a strong surge on the North Wales coast; tides were also high. After its initial failure the embankment at Towyn was rapidly reduced to ground level and the breach grew to 467m long. An extensive area was flooded, including housing with a high proportion of elderly inhabitants. Colwyn Borough Council took six days to seal the breach, using large rocks with concrete pumped into the voids.

NRA staff were initially called out to watch embankments and pumping stations, with the primary aim of keeping the water draining away. They later assisted the council team. The main difficulties in coping with the disaster were caused by the lack of clear organisation and communication. Problems were also experienced with communication equipment. The Welsh Affairs Committee issued a report in July 1990, listing recommendations for future action. These included grant aid for maintenance as well as initial protection, and they also suggested that the roles of sea defence and coast protection should be combined under the NRA. The NRA is amenable, provided that extra funding would be available.

A member of the audience asked how defences would be protected as sea levels rise as a result of climatic change. A survey of sea defences in England and Wales is being completed. On the East coast, risk assessments have been made for the whole shoreline, and used to prioritise work.

Roger Goodhew of Severn-Trent NRA described the Severn Floods of December 1989 to February 1990. Flows on the River Severn were high throughout the period, but three particularly significant events occurred. The flood of 12-28 December 1989 (Flood 1) was mostly fluvial in origin, with a small amount of snowmelt and limited tidal influence. The second flood, which lasted from 23 January to 18 February, was also fluvial, with some tidal effects but no snow. The flood of 26 February 1990 was a sea flood (coinciding with Towyn) and effects were therefore confined to the lower reaches affected by the tide.

Flood 1 was not significant in Mid-Wales, where it had several peaks. As the flood moved downstream these peaks merged and the event became much more significant. Levels are reduced by utilising out-of-channel storage at confluences, for example the Avon confluence at Tewkesbury. The tidal catchment also has a large storage capacity. Levels are affected by the state of the tide well beyond the tidal limit, although at high freshwater discharges the tidal flow is less significant.

Roger then showed an interesting set of slides of the floods, which brought home the extent of flooded areas from Shrewsbury to the estuary. Aerial views illustrated the use of Worcester racecourse and cricket ground as washlands (and also drew attention to a waste tip, established against advice, on the floodplain). Upton on Severn provided a good example of the serious effects of flooding on communications, as it was virtually cut off for several weeks.The problems involved in estimating flow volumes were illustrated by an aerial view of Haw Bridge gauging station surrounded by water, where a team spent an entire morning on one gauging. The return

period of Flood 2 was estimated to be 15-20 years at Tewkesbury and 30-40 years at Gloucester, where the remaining freeboard was only inches.

Generally floodwarning proved very reliable on the main river, giving forecasts based on routing for all areas where 4 hours advance notice is possible. However, once storage in the system is full, the lower river continues to rise despite falling upstream levels, indicating the need for real time telemetry at Gloucester.

On tributaries where rainfall-runoff models are used accuracy was not so high. Below Gloucester the tidal reaches are not yet modelled although work is planned. There is a need for improved surge forecasts. Engineering activity during the events included maintaining the return of water to the main river through outfalls, clearing debris from bridges, and gauging. The Avon sluices could not be managed as they were completely overwhelmed.

During questions it was also pointed out that the proposals for a Severn barrage had not considered the implications for flood defence.

Dam meeting

At the British Dam Society meeting which followed, three speakers presented work on aspects of the East Scotland Floods of February 1989 and February 1990.

Bob Jarvis of Hydroelectric described the exceptional rainfall which caused the flooding. 800mm of rain fell on the Upper Ness and Beauly catchments in January 1989, and a large part of Western Scotland recorded over twice the long-term average with return periods of several hundred years. The main event lasted for 48 hours from 0900h on 5 February, thus fitting neatly into two standard rain days! This in itself increases return periods. IH have calculated a 2-day return period of 100 years for the Conon catchment. Rainfall in Eastern Scotland followed a broadly similar pattern but was less exceptional. The 1990 rainfall pattern was very similar, giving 1.2 to 1.4 times the January averages. Mild weather also caused snowmelt in February.

In both years the major flood problems thus occurred at some distance from the areas of heaviest rainfall, particularly at Inverness, where the railway bridge was destroyed, and at Fort Augustus. The impact of the floods in the Ness, Spey, and Tay catchments is being investigated by consultants.

Hydroelectric operating rules are designed to ensure a substantial measure of flood alleviation. Flood release levels are set; target levels vary seasonally; releases can be increased if the target levels are exceeded. Generation plant can pass 2-3 times mean flow. There is also scope for flow reversal to reduce peaks; for example during the flood Foyars was pumped in reverse in an attempt to lower the Loch Ness outflow level.

Tom Ingles of Highland RPB presented a useful (to those from South of the border) overview of flood management in Scotland. He then described HRPB's floodwarning scheme and improvements currently in the pipeline. Cooperation between HRPB and Hydroelectric was good.

Attention was also drawn to the difficulties of choosing an appropriate distribution to determine flood return periods for short records.

Terry Evans of Mott MacDonald described a study of water management in the Ness basin. No trends were found in the data so there was no evidence for climatic change. The consultants had also investigated the influence of the Loch Ness outfall on both the water balance of the loch and in flood conditions on downstream levels. Alleviation measures considered included lowering the weir crest level, installing extra gates, or an inflatable dam. The last suggestion was received with considerable scepticism by the audience!

Despite the adverse conditions, those who made it to Birmingham had an interesting and informative day. I would also like to extend my personal thanks to the Committee members present, who had to deal with more contrasts in climate than they had anticipated.

Hilary Smithers

ENVIRONMENTAL IMPACT OF THE CHANNEL TUNNEL

BHS Southern Section Meeting
Imperial College, 17 October 1990

Following the signing of the Channel Tunnel agreement between the British and French Governments in February 1986, the successful bidder, Channel Tunnel Group Ltd (subsequently Transmanche-Link Joint Venture and Eurotunnel) pushed ahead with the preparation of the Channel Tunnel Bill. If this Bill succeeded in passing through Parliament without amendments then it would be the first time that plans for such an extensive and prestigious civil engineering project would have by-passed all the normal procedures for the safeguard of public and environmental interests. Without a full public enquiry the only way that objections to the proposed project could be voiced and environmental protection ensured was by introducing amendments to the Bill during its relatively rapid passage through parliament.

The Channel Tunnel Bill was passed by both houses of Parliament in 1986, construction commenced in 1987 and the project is now well under way towards its programmed completion in June 1993. It was therefore with great interest that members and guests of the British Hydrological Society attended this meeting to listen to representatives from the National Rivers Authority Southern Region, Eurotunnel and Wimpey Environmental Ltd to discover how the then Southern Water Authority assessed the environmental risks to its water resources and ensured that any environmental impacts attributable to the project would be detected.

Mr Vipond of the National Rivers Authority (NRA) began the meeting by giving a broad overview of the Transmanche link, emphasising the scale of the engineering works involved. The completed link will include two running tunnels, two service tunnels and regular cross links between the running tunnels and service tunnels. The most advanced service tunnel bore is due to break through at the end of November (1990). The British site is located at Shakespeare cliff and includes an upper tier used for operational control and a lower tier for tunnel access. The tunnel does not terminate at Shakespeare cliff but will extend inland to Ashford where the goods clearance depot and customs posts will be located.

Mr Vipond summarised the regional geology of South East England which is dominated by the Wealden dome structure, and he identified the Lower Greensand and Middle and Upper chalk horizons as being the most significant aquifers in terms of water supply. The chalk is a particular valuable aquifer in terms of water resources because of the excellent quality of water contained within it.

The increased risk of aquifer contamination due to surface runoff from paved areas, the risk of saline intrusion and the possible lowering of the regional water table due to landward tunnelling lead the Southern Water Authority (SWA) to consider it necessary to petition against the Channel Tunnel Bill. SWA were also concerned that the free passage of the Bill would negate the rights given to them within such acts as the 1973 Water Act, 1963 Water Resources Act and the 1974 Control of Pollution Act. SWA petitioned on three main grounds: the inland clearance depot at Ashford would necessitate the expansion of the Bybrook sewage treatment works and the construction of a flood alleviation scheme; surface and foul water drainage control would be necessary at the Cheriton Terminal

site, and finally the possible effects of the landward tunnelling upon the supply boreholes of the Folkestone District Water Company (FDWC).

Eurotunnel responded to the first objection by proposing to contribute to the funding of flood relief structures at Ashford and to the development of increased capacity at the Bybrook works. No environmental impacts were foreseen and the SWA accepted this solution.

The second objection arose because the Bill did not prevent Eurotunnel from discharging the surface runoff from the Cheriton Terminal site directly into the Southern Water Authority's existing sewer system leaving that Authority with the problem of disposal. Eurotunnel agreed to construct a 2.5Km long, 2m diameter relief sewer to discharge the surface water from the completed site.

However, additional problems have materialised during the construction phase arising from the use of sea water to transport the sand as a slurry from the coast to the terminal site. Drainage of the return sea water from the settling lagoons has occasionally caused water quality problems in local streams. This received extensive public attention earlier this year when the NRA effectively strove to minimise the impact of high chloride water both upon the Pent streams and upon the Folkestone Beds aquifer.

A third objection arose when the proposed alignment of the tunnel was made public and found to fringe upon the aquifer protection zones defined by the SWA and FDWC. The concern of the Authority was heightened by the fact that the proposed tunnel is to be constructed in Chalk Marl at the base of the lower chalk horizon (which locally constitutes a major aquifer).

Eurotunnel responded to the objection in two ways: first, local solutions were found to prevent potentially contaminated surface drainage recharging the chalk aquifer, such as the pumped drainage scheme proposed for the new A20 road link; and second, by entering into a written agreement with SWA and FWDC to install a network of monitoring boreholes to assess the impact of the landward tunnel upon the quantity and quality of aquifer water.

Mr Warren, chief site geologist for Eurotunnel then took us inside the tunnel workings with a series excellent colour slides and overheads in order to outline the hydrogeological aspects of the design and construction of the tunnel sections of the Transmanche link.

Although the tunnel is being bored through Chalk Marl, which is practically impermeable (saturated hydraulic conductivity varies between 10^{-1} and 10^{-3} mday^{-1}) the presence of natural springs, such as the Lydden Spout and existing water supply tunnels meant that the possibility of point inflows into the landward section of the tunnel had to be considered during design and construction on the British side. The tunnel boring machine is of 'open face' design, i.e spoil passes straight through the head onto the conveyor system, whereas the French machine can operate in 'closed face' mode enabling it to seal off and drive through areas of high water ingress.

Within the main tunnel bores a concrete lining (expanded segmental lining on the British side and an in situ impermeable, concrete lining on the French side) is placed almost immediately behind the tunnel boring machine. However the lateral cross passage and piston relief tunnels excavations connecting the main tunnels are dug by hand so the opportunity for groundwater ingress is far greater and site monitoring is important (see Figure 1).

To obtain a picture of the ground conditions in front of the advancing British boring machine, probes are drilled along the proposed tunnel alignment. Probes can be up to 240m long and can take up to 4 hours to drill. The site geologist analyses the drill returns and is able to assess the boring conditions in advance. Probes are also drilled into the tunnel floor to identify the Gault Clay horizon and to ensure that the bore proceeds within the chalk marl. Side probes may also be carried out if it is felt necessary. Valves are fitted to all probes to prevent the potential ingress of high pressure groundwater during and after installation of the probe.

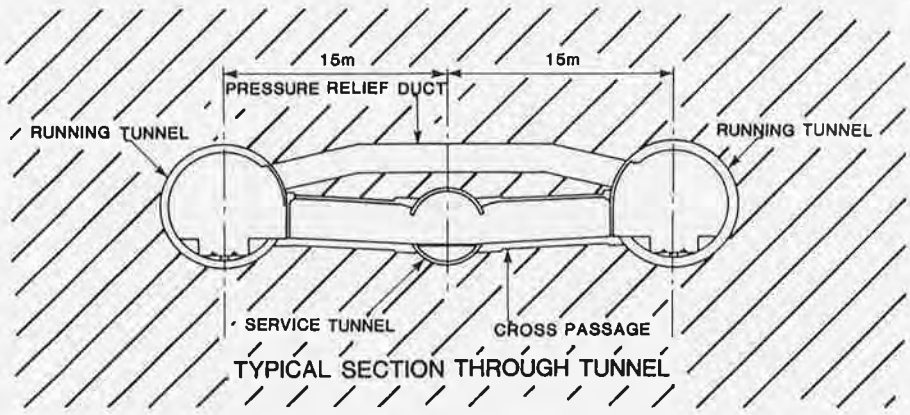


Figure 1. A typical section through the Channel tunnel

Mr Whitaker concluded the talk by giving us details of the network of monitoring boreholes installed by Eurotunnel Ltd. The boreholes (shown in Figure 2) are monitored by Wimpey Environmental Ltd on behalf of the NRA to assess the impact of the tunnel upon water levels and water quality in the supply aquifers of FDWC.

The boreholes were completed in April 1988 equipped with single or double piezometers in the Lower Chalk and the Chalk Marl (see Figure 3). Embedded resistivity arrays, installed in selected boreholes to measure bulk resistivity as an indicator of possible changes in groundwater quality were logged at one-hourly intervals during the first year of monitoring and at two-hourly intervals subsequently. Consequently the project has generated a tremendous amount of data, both of water levels and quality in the chalk aquifers. A total of 184,000 water level measurements were taken in the first two years of monitoring (see Figure 4).

Mr Whitaker explained that the purpose of the data analysis is to identify any residual anomalies which cannot be attributed to natural phenomena such as recharge, recession and barometric effects and to establish whether or not they could have been caused by the tunnel construction. The use of data loggers for automatic water level measurement resulted in a very high quality of groundwater hydrograph, and the effectiveness of the technology is demonstrated by the fact that to date the recovery rate has been 92.8%.

Various anomalies were pointed out by Mr Whitaker and explained in terms of barometric

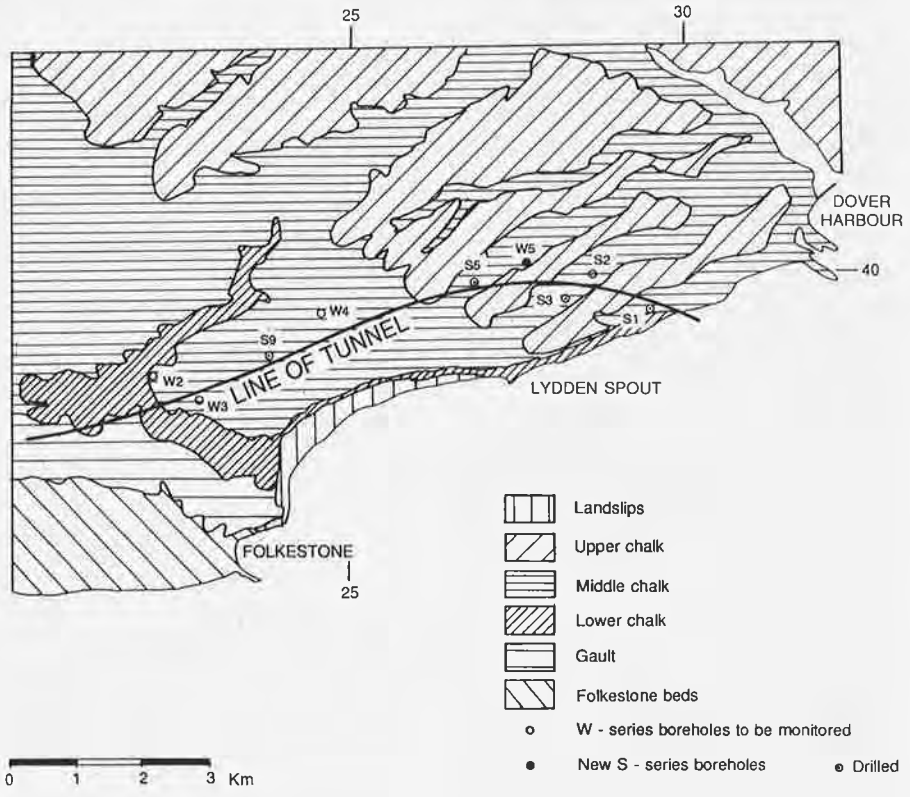


Figure 2. Geological map showing hydrometric monitoring boreholes

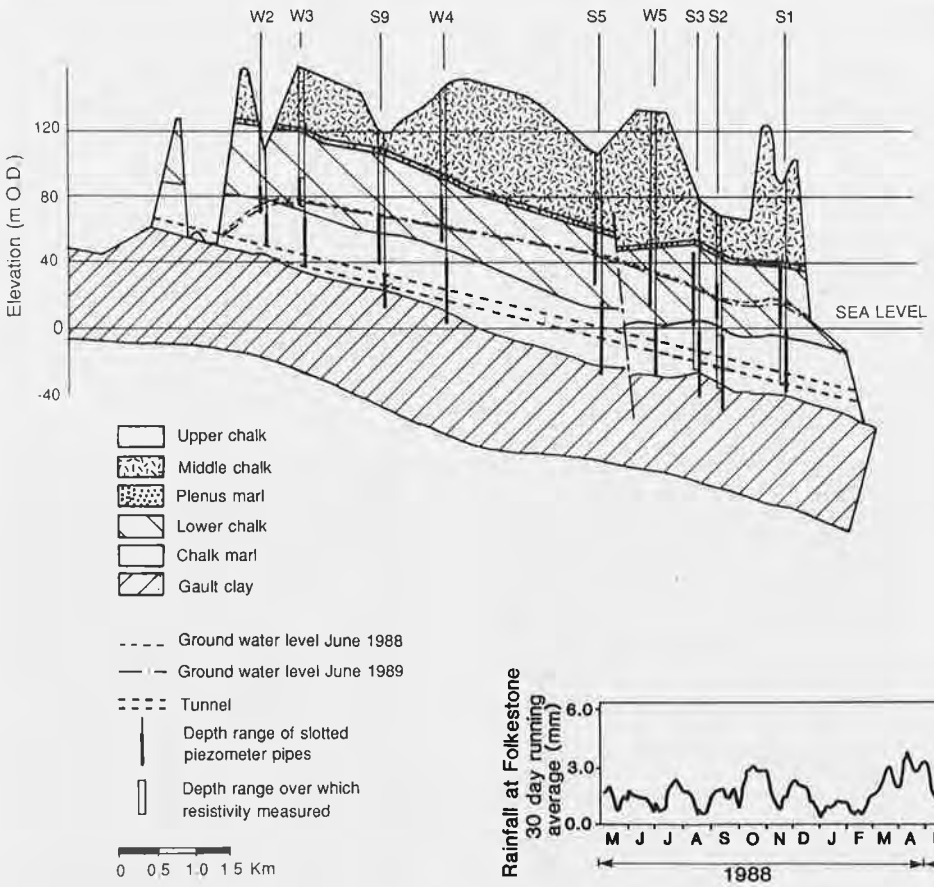


Figure 3. Profile of groundwater levels along the tunnel route

changes, rainfall events and even a blocked transducer venting tube. When the water levels were compared with a relatively crude, historic monthly record at Church Hougham no change in the general hydrograph characteristics could be detected. After a detailed analysis of the complete data set only three residual anomalies remained unexplained. Although each of the boreholes in question was located close to the tunnel alignment it could not be said with any certainty that the construction works were responsible for these anomalies.

Mr Whitaker concluded by emphasising the point that such large quantities of data will often pose many questions previously unasked and tend to highlight the complexity of the system under investigation. The hydrological data collected during the two and a half years of monitoring to date constitutes one of the most detailed sets of observations of aquifer behaviour ever taken in this country. As well as potentially containing evidence of any construction-related effects, the data also record in great detail the complex natural response of the aquifer, which is of particular interest as the period of monitoring includes two drought years.

Discussion

Dr Wheater asked Mr Vipond how the NRA would respond should the monitoring programme reveal that the tunnel construction has had an impact upon the aquifers. Mr Vipond said that the monitoring system was not intended to be an early warning system, but would provide evidence in the event of a claim for compensation from Eurotunnel should any detrimental effects occur.

Mr Wilson went on to suggest that the risk of the tunnel acting as a conduit and causing saline contamination of the supply wells was relatively small given the elevation of the wells and the tunnel, so how could the NRA justify demanding such an intensive monitoring programme: perhaps the NRA had taken advantage of the political situation to enhance their data base?

Mr Vipond agreed that even though the vertical alignment of the tunnel crossed the Ordnance Datum, the water level in monitoring boreholes always remained well above sea level. Only the three boreholes nearest the sea were monitored for water quality. Saline intrusion into FDWC's major sources was never considered to be a possibility. The NRA had been more concerned with the use of sea water slurry to emplace the fill of the Cheriton Terminal site due to the potential for saline contamination and had specified to Eurotunnel which areas were to be filled with clean, washed sand. Mr Vipond did not feel that he was in a position to comment on the politics of the matter.

Tim Jolley

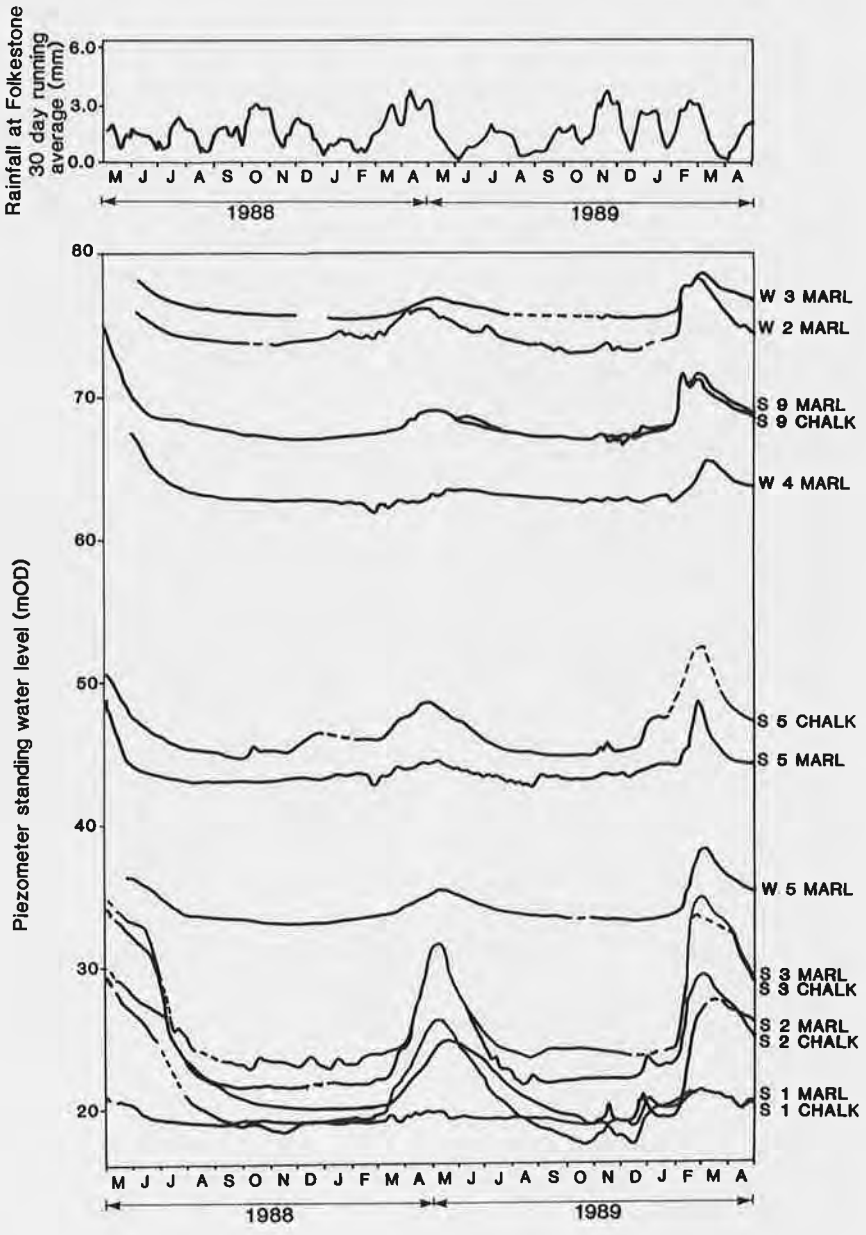


Figure 4. Composite hydrographs and rainfall, May 1988 to April 1989

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Recovery and Rehabilitation of Rivers

BHS Midlands Section Winter Meeting 21 November 1990

Prior to the paper presentation, BHS President *Allan Lambert* welcomed delegates to the meeting. He outlined the national and international initiatives with current BHS involvement together with the programme of future meetings. He stressed the need to increase membership and encouraged all non-members present to join the society.

Diminishing river flow is a subject of national concern. Public conception of the problem of artificially induced low flows in streams and rivers has been enhanced by two summers of drought conditions and considerable media attention. The interest and concern of all parties involved with the water environment was well demonstrated by the attendance at this meeting of more than 70 delegates of varied backgrounds.

The first presentation of the afternoon *Alleviation of Low Flow*, by **Elfyn Parry** (Severn-Trent Region NRA), **David Izatt** and **Hugh Goldsmith** (Howard Humphreys) concentrated on the influence of groundwater abstraction on river flow. Elfyn Parry controversially introduced the paper by questioning whether the current abstraction licences would be issued by the NRA with the hindsight of the effects on the catchment? Groundwater abstraction is a dominant factor influencing stream flow, by either intercepting the natural baseflow or inducing leakage through the river bed. Protection of the baseflow raises conflict between protecting the environment e.g. riparian rights, WRW effluent dilution, fisheries and conservation, and developing groundwater resource abstraction.

The assessed resource was defined as the long-term rate of infiltration into the aquifer, in simplistic terms: rainfall - evaporation = resource. It was pointed out that although the licensable resource is variable it should always be less than the assessed resource as some groundwater has to be left to protect the baseflow in streams. Examples were given of groundwater management units in the Sherwood Sandstones (Figure 1) where abstraction exceeds the assessed resource and therefore has a detrimental affect on natural streamflow.

Nationally, 40 catchments have been identified with "real" problems where historic abstractions have clearly had a significant environmental impact and where, if there was a change in abstraction policy, a benefit to the stream could be gained. Six problem watercourses have been identified in the Severn Trent Region. Most of these sites suffered since the turn of the century from depletion of river flow due to groundwater abstractions which now have Licences of Right issued under the 1963 Water Resources Act. In all cases the licensed resource and actual abstractions exceed the assessed resource of the aquifer.

Consultants Howard Humphreys were engaged to carry out an independent assessment of the six sites. David Izatt outlined the terms of reference for the currently ongoing study which encompasses aspects of hydrology, hydrogeology, water quality, fisheries, conservation and social history.

He raised the issue: to what extent is the renovation of the catchment possible and desirable? It is unlikely that there will be any real

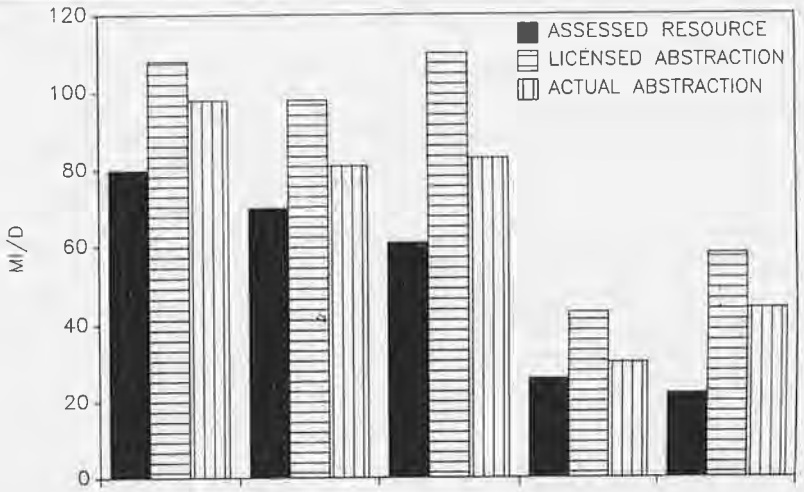


Figure 1. Groundwater management units, Sherwood sandstones aquifer

short-term gains for the catchment as a whole, but short-term solutions are possible for particular river reaches with water quality or flow loss problems. The NRA and major users should address the requirement for the necessary long-term policies. **Hugh Goldsmith** described the study in more detail, identifying the common features of the six catchments: rural catchments near urban areas, on the Sherwood Sandstones aquifer, large numbers of PWS abstraction boreholes with Licences of Right. Each was historically a working watercourse with many pools and lakes creating artificial wetland sites. The Licences of Right issued in 1963 were based on the previous five years abstraction, taking little account of the resource available. Where the safe yield of the aquifer is being exceeded so the long-term security of supply cannot be guaranteed.

Historically the PWS abstractions were developed as the sources were local to the urban areas, this in turn created conflict with mill-owners who were compensated financially and with mains water supply. This effectively permitted the development of what is now considered to be the over-abstraction of the groundwater resource. At the same time sewage works discharges were increasing, compensating in some areas for the loss of quantity of flow, but at the cost of quality.

Recent influences include the increase of abstraction for irrigation purposes, limited not by demand but supply, the resources being managed by the NRA.

The Dover Beck catchment in Nottinghamshire was selected as a particular example of the problem encountered. The headwaters and the first third of the length of the Dover Beck catchment are on the unconfined section of the Sherwood Sandstones: for the rest of its course the Beck flows over the aquifer confined beneath the Mercia Mudstones before discharging into the River Trent. In the 1850s there were seven working mills on the Beck, flow to the lower reaches being controlled by the Salterford Dam. At the turn of the century the Beck was a famous trout fishery, but also at this time the headwaters began to dry up.

Groundwater abstractions have depleted baseflow such that the Salterford Dam, a grade 1a & 1b wetland conservation site, dried up. Conservation effort is centred on the Oxton Bogs, another graded conservation site further downstream. In 1990 there is no recordable baseflow for approximately half of the Beck's length, flow in the lower reaches is maintained by the discharge from Calverton WRW. In the past few years the flow has been reduced when a continuous discharge from a groundwater fed fish farm ceased, effectively reducing the dilution available for the WRW effluent thus causing a drop in river quality.

In restoring river flows it is not just necessary to consider volume; quality and the benefits to the aquatic and bankside flora and fauna are of equal importance. At this stage water quality classifications, biological and chemical, are the only measure of improvement. The presentation was concluded by questioning the basis for restoring flow. For most catchments there are insufficient flow data for the pre-1963 status, some data are available for the Dover Beck (Table 1). What would be the flow condition that a restoration target should achieve?

Richard Douglas (Severn-Trent Water) opened the discussion, stating that Severn-Trent were currently undergoing a phased abstraction reduction in the area as better quality (low nitrate) sources in the confined aquifer were exploited . He asked if there had been any noticeable effect and whether the further planned reductions would achieve the restoration of the Dover Beck? Elfyn Parry replied that the flow of the Dover Beck had not shown any significant signs of being restored but the reduction in pumping had benefited the wetland areas. **Keith Harris** (Halcrow) agreed that pre-1963 flow data was at a premium and therefore flows had to be predicted. One option was to model the aquifer at pre-development conditions, rainfall would equate to the available resource and baseflow could then be predicted. Elfyn Parry replied by questioning the need to restore flows to this degree, enhancements should be to a level that gives maximum benefit to all catchment users.

John Eastwood (Wessex Water) asked what the next steps were for the NRA on receipt of the report. In reply Elfyn Parry said that, in the Severn-Trent Region the recommendations in the report from phase 1 of the study would be assessed. In addition, a uniform approach regarding low flow problems is now being considered nationally. In phase 2 selected catchments would then be looked at in more detail and remedial action undertaken if necessary in phase 3.

Andrew Heaton (Severn-Trent Region, NRA) highlighted problems of acceptable flows for conservation purposes, the first being the identification of the natural state of the river. Another problem is whether a minimum water depth of 5 cm will produce as much diversity of habitat and fauna as will 30 cm. The discussion on rehabilitation led into the second paper:

How do we address the problem of what is the optimum level of restoration? A methodology which may answer this question was presented by **Geoff Petts** and **Max Wade** of Loughborough University in their paper *River Restoration: The Channel and Beyond.* River restoration is important for agricultural and industrial activities, and conservation, recreation and amenity purposes. Restoration influences the river channel, the riparian zone and the flood plain. Restoration therefore must focus on ecological functions rather than a structured engineering approach.

Geoff Petts gave an example of this approach, the River Gwash, originating on the Lincolnshire Limestones and flowing over an area of river gravels. This causes severe water loss before the lower reaches of the river. When flow at the Kates Bridge gauging station falls below 24 Ml/day net transmission losses occur. This occurred for 17% of the time for the period 1960-86. The solution is to transfer water from Empingham reservoir when the flow dropped below that threshold.

The decision to augment the flow was taken after an Environmental Assessment of the river to assess the optimum flow for conservation and environmental enhancement. Effort was concentrated on those reaches defined as the minimum and optimum for restoration. Physical and biological data were obtained for the River Gwash and a wide range of similar sites in the Anglian Region, NRA. The information obtained was used in flow/habitat models and biotic response models, e.g. PHABSIM. By modelling the BNWP score, for benthic organisms, the effect of maintaining the baseflow above 24 Ml/d could be determined. The models predict that a transfer of water will produce a major improvement of the riverine habitat. It is hoped that when the scheme commences in 1991 this prediction will be validated.

Benthic organisms are not the only beneficiary of flow restoration. As well-proven methods of classification exist, habitat improvement can be classified using benthic organisms. Restoration of flow will permit restoration of habitats extending from the river. Max Wade demonstrated the potential for restoration of the riparian area and flood plain. Using an example of the River Trent flood plain near Gunthorpe, Nottingham, he showed how the potential can be determined by studying preserved river corridors and historical land use records. Classification systems are poorly defined and the value of certain habitats can only be defined by the diversity of species present.

***Table 1.** Dover Beck: Changes in Low Flows, 1886-1990.*

YEAR	FLOW (Ml/day)	COMMENTS
1868	29.0	Minimum flow recorded by Borough Engineer
1894	18.0	Minimum gauged flow after 12 years of low winter flow
1973	6.9	MAM(7) at Lowdham weir
1976	1.6	Minimum gauged flow on record
1989	3.2	MAM(7) at Lowdham weir
1990	2.0	Gauged flow on 11 September 1990

Restoration of habitats can be achieved by reducing bank slopes, building in wetland areas into flood defence programmes, selective planting to intercept nutrient loads. Low flow alleviation is the starting point to manage water resources for ecosystem management. The restoration of the riparian area is no conservation alternative to natural wetlands. To present options for river flood plain management it is necessary to look at what the cumulative potential uses are for all habitats.

The chairman of the meeting **John Pirt** (Severn-Trent Region, NRA) opened the discussion by pointing out that many of the flood plain proposals, e.g. tree planting, would be in conflict with the NRA's flood defence policies. **Nick Haycock** (Oxford University) stated that effective reduction of nutrient transfer from agricultural land to the riparian zone was necessary in order to protect the restored ecosystem. This could be achieved by using sediment/nutrient traps. It was agreed that information on the contiguity of soil/river systems was a necessity for development of future management models. The hydrology and soil type were the greatest influences on riparian habitats.

The discussion closed with examples of breaks in recession curves being identified as happening in the Anglian Region at the end of the harvest season as the demand of crop transpiration ceased. In Severn Trent Region this had been noted at the end of the irrigation season on the River Severn, and in the Southern Region at the end of the summer holiday period.

This lively, well-attended meeting indicates the current interest in the recovery and rehabilitation of rivers. The theme will be continued in a session at the forthcoming BHS National Symposium.

John R W Adams
Severn-Trent Region, NRA.

Thames and South Coast Floods in the Winter of 1989-90

BHS-IWEM meeting at Imperial College 12 December 1990

Welcoming the large audience, BHS Southern Section's *Nigel Arnell* remarked that this was the third occasion that the Section had a joint meeting with the IWEM Metropolitan Branch and that such arrangements were clearly popular. The talks related to the 1989-90 floods, and were to cover both fluvial and coastal flooding, by authors whose jobs had put them into the front line of coping with such occurrences.

Colin Martin of Mouchel Management Ltd., Project Manager for NRA Thames Region on the Maidenhead, Windsor and Eton Flood alleviation scheme, gave an information-packed account of the flood events affecting the Maidenhead area between December 1989 and February 1990.

First came a bankfull discharge of 265 cumecs on 21 December 1989 following 155 mm of rain in the 14 previous days. There followed a further 91 mm in January 1990 and 131 mm in the first three days of February. This total of 131 mm included particularly heavy rainfalls in the south, swelling the Blackwater (Loddon) and Kennet tributaries considerably. The consequent accumulation of flow in the Thames led to 14 days of flooding in its middle reaches, with over 550 houses affected in Maidenhead, 40 of them severely. Some houses had to remain unoccupied for a further three months. Several householders moved their vehicles to higher ground, only to suffer vandalism of their unsupervised property. Other needless bother was caused by curious visitors driving past and sending bow waves into gardens.

Much of the flood water had followed an old water course, the Clappers Stream, whose ancient watermeadows had been built over in recent years. It was intriguing to see an aerial photograph of the old causeway at Cookham restored to temporary use, clear of the floodwater, whilst the modern bridge that replaced it was under water. Maidenhead town centre remained dry, thanks to a recently-completed flood relief scheme.

At its peak between 5 and 10 February 1990, the river flow at Boulter's Lock had exceeded 320 cumecs. This might be compared with previous flood events (Table 1).

In respect to frozen conditions, other years have been worse than 1947, e.g. 73 days in 1962/63, 49 days in 1940 and 48 days in 1942.

Colin Martin remarked that in evaluating flood statistics, duration probabilities as well as peak discharge probabilities deserve to be reckoned.Questions from the audience focussed on the new flood relief scheme for Windsor and Eton and its reaction on downstream areas, on the true return period of the 1947 flood (was it not 40 years, rather than the 65 years assumed in the Windsor scheme?) and on bankfull capacities upstream of Boulter's Lock. The author said that the new flood relief scheme, one of the largest to be constructed in the UK at a cost of £40M, would, under the worst circumstances, only raise downstream water levels by 19 mm. Upstream of Maidenhead, repairs to the towpath would contain a bankfull discharge of 290 cumecs.

Table 1. *Flood events at Boulter's Lock, River Thames*

Year	*Rainfall in 14 days prior to flood (mm)*	*Flood discharge (cumecs)*
1947	80*	516
1954	95	327
1960	98	330
1989	155	265
1990	100	331

*onto ground that had been frozen for 46 days.

David Martin of NRA Southern Region (standing in for his colleague Tony Branch) then turned the tide of attention to sea flooding. This is often the combined consequence of the astronomical tide and meteorological conditions, the latter causing storm surges in the North Sea after a spell of northerly gales, or in the English Channel after south-westerly gales. Storm surge models for the English Channel are still being refined, whereas those for the North Sea are reasonably accurate.

Striking slides were shown of the erosion of parts of the Sussex and Kent coast during the 1989-90 winter. The NRA's sea sefences there are mostly shingle embankments, which successfully resist the ordinary twice-daily high water, but are liable to excessive seepage under sustained high water conditions. When severe storm damage occurs it is not always an option to bulldoze the shingle back from the beach and land-based shingle sources have to be found. Admittedly such sources are finite, whereas coastal sources are virtually inexhaustible, though care has to be taken not to interfere with natural beach nourishment processes.

With the protection given by sea defences, some seaside property owners had taken unwise risks in adding expensive extensions to their bungalows, at sites where erosion is rapid. At Bracklesham the last winter's storms had shifted 20 ton blocks bodily inland. The use of rock groynes was a longer-term measure, but they have proved unpopular on visual grounds. To improve their maintenance capability for the south coast defences, the NRA is creating access roads immediately behind the embankments. Current NRA sea defence schemes include significant improvements at Lymington, Elmer (by Bognor Regis) and Dymchurch.

Turning briefly to fluvial flood control, the author showed two flood storage reservoirs, one near Tonbridge and another above Ashford, which had filled for the first time last winter, proving most successful. **Marie Lindley** supplemented this with slides of the associated hydraulic control structures, including a giant vortex hydrobrake for regulation of the Aldington reservoir outflow.

Subsequent discussion included suggestions of using colliery shale or clay as core material in embankments to reduce seepage. There was also reference to areas where the joint probability of fluvial and storm surge flooding should be reckoned. The author recognised that such cases existed in his area, notably at Lymington in Hampshire.

The meeting concluded with thanks from **Alan Bruce**, on behalf of IWEM, who endorsed Nigel Arnell's hope for further joint meetings with BHS.

John Cole
WRc, Medmenham

Groundwater Quality Modelling

Geological Society/BHS/IAHR Joint Meeting 22 January 1991

This one-day, jointly-sponsored meeting was held at Burlington House, Picadilly, London. A total of seven papers were presented, dealing mainly with the modelling of groundwater flow and contaminant transport. The presenters were drawn from universities, consulting firms and government bodies, as were the participants (numbering about 160). A variety of hydrogeological modelling techniques currently in use and under investigation in the UK were aired and discussed. The uncertainties in modelling highly complicated natural systems were also highlighted.

The meeting opened with a presentation by **Howard Wheater** and **A.P. Butler** of Imperial College who discussed the difficulties of determining soil hydraulic and transport parameters and of representing soil structural effects in the modelling of solute transport in the unsaturated zone. They presented a model for simulation of radionuclide transport in the unsaturated zone including processes of adsorption and plant uptake. In this application, numerical modelling was supplemented by lysimeter experiments to study the movement of radionuclides above a contaminated water table in the context of radiological safety assessment.

Next, the complexity and uncertainty in representing transport in fissured geological systems was investigated in a contribution by **J.A. Barker** of the British Geological Survey using, as a case study, pollution from motorways entering soakaways in highly permeable chalk, infiltrating to the water table and possibly contaminating well supply. The difficulties in obtaining parameter values for the two types of porosity inherent in such systems even with the aid of tracer experiments were emphasized, and a simplified modelling approach advocated in view of this paucity of information. As expected, the system provides for both a fast response and a slow response.

The third contribution by **K.M. Buckley, K.J. Beven** and **A.M. Binley** of Lancaster University focused on methodologies for groundwater transport in structured porous media. The shortcomings of the classical advection-dispersion theory led the investigators to formulate a random walk model incorporating both deterministic and stochastic principles to define the pathways of large numbers of particles simulating dispersion. This particle tracking approach was reported to be highly flexible, but because of the necessity of specifying large numbers of particles and the fine space-time steps used, it was computer intensive. A further idea involved the use of fractal concepts to generate velocity fields and particle paths without the necessity of specifying a medium. The fractal paths generated were self-similar over a range of scales.

Discussion from the floor after the presentation of the first three papers reflected concern with the uncertainties associated with modelling particular components. The effectiveness of tracer experiments was questioned by **Dr Stephen Foster**, who cited as illustration a figure of only 1% for the recovery of tracers. This was explained as being largely due to the difficulty of detecting dilute concentrations of tracers as well as the short time lengths and the sparseness of observation wells in most tracer experiments. The necessity of including a vapour phase in unsaturated zone modelling was brought up as was the need for realistic evapotranspiration data. With regard to the latter, the presenters of the first paper replied that although representative off-site data had been used in the preliminary modelling phase, the later phase would employ site measured data. Finally, one participant expressed doubt as to whether modelling without reference to a medium would lead to a practical resolution of real problems.

The afternoon session began with the presentation of a solute transport modelling case study by **J. Larkin** of Dames and Moore. The purpose of the study was to determine, through simulation, the applicability of various remediation solutions for a contaminated chalk aquifer. The model was based on relatively detailed geological information, and a 14-day pumping test which allowed the hydrogeological characteristics to be assessed. A 2-D finite element model was used which treated the fracture medium as a continuum and considered rock matrix diffusion for each node and at each time step. The model grid was orthogonally aligned with the site fracture orientation to reduce numerical dispersion. Both constant head and no flow boundaries were used and were set just outside the radius of influence of on-site abstractions. Model parameters were chosen and calibrated using information from the tracer test. The model results were used to assess the relative merits of alternative containment and remediation options.

Next, **Daniel Oakes** from WRC talked on the modelling of diffuse source pollution, presenting a simple model for nitrate leaching. Analysis of soil profiles showing nitrate movement over time has led to the development of a simple "black-box" transfer model for the unsaturated zone. This connects to a saturated zone model and provides a link between farming activity and leaching to the rock beneath. Empirical rules govern percentile nitrogen leaching losses for various land uses. The groundwater model uses a dual porosity fully mixed cell method to calculate nitrate concentrations. Dual porosity is considered by way of different matrix and fissure concentrations linked by a first order rate equation. Model simplicity enables mobility between catchments without the need for specific soil surveys. The method has been used to identify nitrate sensitive areas and aquifer protection zones in over 20 catchments with a variety of underlying rock forms.

Mr Graham of Anglia NRA opened the comments from the floor, questioning the use of fixed head boundaries since these impose a rigid flow field which may be an unacceptable assumption. **Mr Johnson** inquired as to how the model as used by Mr Larkin dealt with diffusion between the fissure and block. Dr MacKay answered that the model allows for time dependence of block contribution. Dr Wheater also questioned the use of chalk-derived parameters for catchments of all rock types in Mr Oakes's model.

After an adjournment for tea, the programme was resumed by **Ray MacKay** of Newcastle University who presented a case study illustrating the use of stochastic methods for contaminant transport analysis. The study concerned the prediction of contaminant migration from a hypothetical low-level radioactive disposal site in the Oxford clay. Site geology was represented by a simplified 3-D modelling system. Geostatistical methods characterised the uncertainty of hydraulic properties of sand strata underlying the clay repository site. The system was calibrated using deterministic modelling. Media realisations acted as inputs to the particle tracking approach. Monte Carlo simulations were then used to identify potential contaminant pathways and analyse associated uncertainties for a site risk assessment.

Finally, **Bob Harris** of Severn-Trent NRA raised the question of the use and the value of models. He saw them as beneficial to practitioners in three main areas: in the choice of clean-up methods, and as an aid to consent decisions and policy determinations. He highlighted the major problems of modelling to be data availability, difficulties in dealing with transport, lack of user involvement in development and lack of user acceptance. Mr Harris identified the difficulties in user acceptance: models are seen as the province of non-practising academics, models relying on large amounts of costly data (often unavailable for development proposals). Practitioners tend to see models not as tools but as answer machines and find it difficult to accept that uncertainties may lead to a range of results. Moreover, despite the wonders of modern graphics, presentation is still generally poor.

Points that should be considered before using a given model were then suggested. These concerned the suitability of the model operator's background, the compatibility of model and data, and whether model use and data collection are integrated. Mr Harris concluded that predictions are often made by instinct and speculated that models are perhaps an extension of this and should be used as a guide rather than as a replacement for human judgement.

Points were then raised from the floor. **Dr Jeffries** from Queen Mary College, London,

pointed out that the chemicals transported in the medium may change the permeability of the medium. Dr Foster said that models allow an honesty in the treatment of uncertainty, but it is important that the regulatory bodies accept this uncertainty. Mr Harris suggested that EC directives may be preventing the consideration of uncertainties due to the imposition of too stringent regulations. Dr MacKay continued this theme, concluding that grey areas exist in all areas of risk and this should be considered by decision makers. Finally, **Mr Thomas** addressed the issue of result presentation, saying that the better the presentation, the less uncertain the results look: perhaps the usual string of numbers would be more appropriate.

Mr Johnson concluded the meeting by noting the evident strong interest current in the UK in groundwater contamination and how to assess and treat it. Further collaborative meetings are a good way of sharing experience.

Jacob Tompkins
Kien Gan

Landslides in New Zealand

***James Bathurst* recently visited the Department of Scientific and Industrial Research (DSIR), Geology and Geophysics Division, at Christchurch, New Zealand, to study landslide erosion, supported by a Churchill Travelling Fellowship. The visit was carried out as a contribution to the current development of a landslide erosion and sediment yield component for the Système Hydrologique Européen (SHE) hydrological modelling system in a team project at the NERC Water Resource Systems Research Unit, University of Newcastle upon Tyne. In this article James describes the joys of landslide research in the exciting environment offered by New Zealand.**

The start of our landslide erosion and sediment yield modelling project at Newcastle coincided with the offer by the Winston Churchill Memorial Trust of Travelling Fellowships to visit New Zealand, commemorating the 150th anniversary of the signing of the Treaty of Waitangi in 1840. Churchill Fellowships, which form an annual tribute to Sir Winston Churchill, allow men and women from all walks of life to gain a better understanding of the lives and work of people in other countries overseas and to acquire knowledge and experience which will make them more effective in their work and community when they return.

Our study is concerned with the addition of a physically-based landslide erosion and sediment yield component to the SHE, enabling the downstream impacts of rain and snowmelt triggered landsliding to be simulated. The SHE flow modelling system will provide the framework in terms of topography, soil characteristics, vegetation characteristics and soil moisture conditions. The new component will then use this information to determine when and where shallow translational landslides are triggered and what their impact is on catchment sediment yield.

The model is intended to be of use in examining the effect that land use change, such as hillslope deforestation, may have in decreasing slope stability and increasing the input of eroded material to river systems, so causing damaging impacts in the form of reservoir siltation, flooding and reducing water quality.

However, there has been relatively little previous work in developing models of this type: the first step in our project was therefore the accumulation of the necessary body of information with which to determine the structure of the model and how it might be used. A Fellowship to New Zealand seemed to provide a pretty good route to attaining this background since it would provide opportunities for literature review, discussion with experts and field visits. I duly applied and was searchingly interviewed by a panel of impressive and eminent persons. Having eventually been awarded a Fellowship I packed my winter clothes and headed to New Zealand for two months, beginning in August 1990.

New Zealand is a highly suitable country in which to study landslides because it is more or less composed of them! Active mountain-building processes, high rainfall, the occurrence in certain areas of easily erodible soils and the deforestation caused by Maori and European settlers contribute to one of the more dynamic geomorphologies in the world. One consequence has been the development across the country of a number of centres with international reputations in the study of landslides and their impacts. I based myself at Christchurch at the DSIR Geology and Geophysics Division, formerly the New Zealand Geological Survey and possibly to be so again. (Over the last few years DSIR has been reorganized with an enthusiasm that makes UK Research Council strategy look positively timid!) My host colleague at the Division was **Dr Mauri McSaveney**: I was also able to meet with scientists working on landslide erosion at other DSIR divisions in Christchurch, the Forest Research Institute and nearby Lincoln University.

Even as I flew towards Christchurch, a huge brown plume was staining the sea off the north end of the South Island. This turned out to be derived from a major flooding and landsliding event concentrated around Motueka, near Nelson. No sooner was I over the jetlag than I was whisked up there to look at the erosion with a team from the Forest Research Institute. The visit provided a good introduction to rainfall-triggered landslides and their impacts. Slips, the name given locally to shallow landslides, were widely evident in the area, roads had been blocked, houses had been damaged by debris flows and orchards had been silted up. Cleaning up operations were still in progress and, to judge from the enormous pile of muddy boots outside one of the bars, these were proving a thirsty business! Meanwhile, I was hurriedly revising my ideas on landslide modelling.

A particularly useful outcome of the visit for me was an improved appreciation of the topographic detail which would need to be incorporated in our model if it were to represent landslide formation with the desired physical basis. Many of the slips in the Motueka region were individually not large and it was clear that the model grid squares, used to represent spatial variation, would have to be quite small, around 20 x 20 m^2, to support simulations at the correct scale. In terms of modelling the downstream sediment yield of landslide erosion, it was also of interest to note in what circumstances the material from the landslide scars was able to slide as far as the stream network. In many cases the material was simply redistributed on the hillside, although from here it could still contribute to the stream sediment load via overland flow.

After an interlude carrying out my literature review at Christchurch, I made a second field visit, to the Southern Alps with Mauri. We drove down the west coast, following the remarkable ruler-straight line of the main Alpine Fault. This is an area of active mountain building, the peaks thrusting upwards at the rate of a centimetre a year. However, because of the resulting steep slopes and a quite phenomenal annual rainfall (measured in fathoms), erosion takes place at the same rate. Landslides can be seen on every hillside (rather larger than at Motueka) and colossal quantities of gravel are transported towards the sea, first by debris flows and then by fast-flowing braided rivers. In places the gravel production is so great that road bridges are threatened with burial.

Most of the hillsides are vegetated with dense rainforest and this trip therefore provided a useful view of landslide development under forest cover. The tree roots provide considerable reinforcement of the soil against failure but, when a landslide does occur, the energy and mass of material involved is much larger than would have been the case in the absence of trees.

After reviewing more literature I made a third tour, this time of research groups in the North Island at Wellington, Taita, Aokautere and Gisborne. Two excursions to the eastern side of the island showed the widespread havoc that had been caused by Cyclone Bola in March 1988. Hillsides in the Napier area were so peppered with slips that around 10 percent of the sheep pasture had been lost. Deforestation of the region by settlers also seems, through removal of the root reinforcing effect, to have contributed to a general increase in hillslope instability and soil erosion over the last century.

The consequences are evident in the infilling of valley bottoms (a process recorded in lake cores and soil profiles) and the massive siltation of the rivers. Channel cross sections have been reduced and floods which could previously be contained are now likely to spill outside the channel. Some success has been achieved in stabilizing hillslopes and reducing

erosion by reforestation programmes. However, these cannot remove the material already in the rivers. Thus, as the sediment waves move away from the headwater areas, they pose, with the inexorability of a time bomb, a threat of increasing flood frequency for downstream towns like Gisborne.

These three field visits provided me with a good "real world" view of landslide erosion and its impact on sediment yield. As intended, they complemented the information I obtained from my literature review and from discussions with scientists at the various New Zealand research centres. Probably the most valuable outcome of the whole trip has been an improved specification of what should be built into our model and a realistic objective in terms of what we should expect to achieve with it. I am now writing my visit report which will cover the factors affecting landslide formation and the approach to modelling the landslide trigger mechanism, the volume of material eroded and the impact of the eroded material, in particular whether it reaches the river system. The report will then form an input to the design and formulation of the SHE landslide component.

Many memories of my visit remain with me, reinforced by a stack of slides (photographic, not slips). The scenery, lack of crowds, hiking in the Southern Alps and the luxury of being able to work single-mindedly on just one subject for two months, all were enjoyable. A particular revelation was that I could not be reached in real time by telephone from the UK during office hours and even faxes could be treated with some condescension! (Here, however, I should pay tribute to my colleagues at Newcastle who covered for me during my absence.) What most impressed me, though, was the warmth and friendliness with which I was received by my New Zealand colleagues. Invitations to participate in field trips, time for discussions, pointers to useful literature and offers of hospitality were provided unstintingly and created a relaxed and enjoyable environment in which to carry out my studies. I look forward to maintaining the resulting contacts and friendships.

James Bathurst

American Water Resources Perspectives

***Kathleen Lacey**, currently researching urban water quality at the Water Resources Institute of Grand Valley State University, Grand Rapids, Michigan, while on sabbatical leave from Kingston Polytechnic, sent us this report of the Urban Hydrology symposium of the 26th Annual Conference of the American Water Resources Association. Kathleen thought BHS members might be interested in the American perspective on some of these water resource issues.*

The 26th Annual conference of the American Water Resources Association was held in Denver, Colorado, in November 1990. The keynote speaker was **John M. Sayre**, Assistant Secretary of the US Department of the Interior. Sayre presented information on the initiatives currently being developed by the US Bureau of Reclamation and the US Geological Survey on the two issues of Science and Education and Water Resources Management.

Sayre acknowledged the tremendous potential of the Interior Department to entice students into science. In line with Presidential policy on the promotion of Science Education, the Interior Secretary, **Manuel Lujan,** has chosen *'Excellence in Education'* as one of four major Secretarial Initiatives and is promoting educational outreach in all 10 Interior Bureaux. The USGS, the Bureau of Reclamation, and the Bureau of Land Management are collaborating with the American Water Resources Association in a joint education initiative to stimulate interest in, and provide basic knowledge of, water resources for students from five to eighteen years old. Teaching aids and training packages will be produced from this collaboration which will ultimately be distributed by the National Science Teachers Association to over 60,000 science teachers.

Sayre also presented his perspective of the current thinking in water policy in the executive branch of the Interior Department. According to him, one of the most important contributions to water quality and water quantity is the development of the National Water Quality Assessment Program (NAWQA). This programme has three main goals:

1) to obtain baseline information on water quality conditions
2) to identify trends in water quality
3) to describe natural and human factors that cause changes in water quality.

The USGS is committed to meeting goals in a way that will provide local, regional and national information on water quality. To meet these goals the data must be geographically consistent. Strict quality assurance procedures and field methodologies are being developed to ensure that analytical results are comparable and transferable. Identifying trends in water quality requires a long-term commitment. The NAWQA program is based on a repeat cycle of approximately 10 years. Sayre was particularly pleased to announce to the conference the recent endorsement of the Interior's NAWQA Plan by the National Research Council.

The conference was organised into two main symposia, both published. The Transferring Models symposium was organised in recognition of recent rapid advances in the hydrological component of Geographical Information Systems and new applications of expert Systems and Decision Support techniques to water resources issues. Symposium sessions also covered numerical groundwater modelling and water quality modelling.

The attention of delegates attending the Urban Hydrology Symposium was acutely focused on the new storm water quality regulations, coincidentally published on the first day of the conference. These were finally added to the Federal Register, after eighteen years of discussion, debate and compromise. This long gestation period should not detract from the fact that American water resource scientists have still progressed more rapidly than their British counterparts in storm water quality management. The 1980 US EPA Nationwide Urban Runoff Program clearly identified storm water as having a negative impact on receiving waters. Two recent reports, *'The National Water Quality Inventory 1988 Report to Congress'* and the 1985 *'America's Clean Water: The States Non-Point Source Assessment'* both reported urban runoff as a major cause of impairment of the resource value of watercourses.

The regulations require all industries, and large (>250,000 population) and medium size (100,000-250,000) municipalities, to obtain National Pollution Discharge Elimination System (NPDES) permits from the Environmental Protection Agency for their separate storm water discharges. This has two main aims:

1) To effectively prohibit non-storm water discharges into storm sewers by focusing attention on illicit connections and illegal dumping to storm sewers, and

2) to encourage controls to the maximum extent practicable to reduce discharges to storm sewers.

The regulations do not define what is meant by 'maximum extent practicable', thereby providing scope for flexibility and compromise between permittee and the EPA depending on management and system techniques.

To characterise the discharges, permit applicants have to define the storm water quality by the conventional pollutants (oil and grease, pH, Biological Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead and zinc) for selected storm events. Annual pollutant loads and event mean concentrations have to be supplied. If organic pollutants, toxic metals, cyanide and total phenols are expected to be present, quantitative data on these determinands have to be supplied also. As well as characterising discharges, storm water quality management programmes must also be submitted. The management programme should include descriptions of the structural and source control measures to reduce pollutants from runoff which enters separate storm sewers, maintenance activities for the structural controls, practices for operating and maintaining public streets, roads and highways, and procedures that assure that any flood management project also addresses the impacts on water quality. A comprehensive master plan has to describe the planning procedures necessary to reduce pollution in areas of new development and significant redevelopment.

These new storm water regulations will certainly mean more involvement for hydrologists and water quality scientists from State agencies, universities and consultancy firms, both in the sampling and analytical programmes and in the production of storm water management plans. However, the administrative and financial burden of compliance with the regulations, and enforcement of the legislation, should not be underestimated. Municipalities which have been progressive and have developed storm water quality management programmes in advance of the legislation have shown that beneficial improvements in urban water quality are possible.

Kathleen Lacey
Water Resources Institute
Grand Valley State University, Michigan

New IH Publications

The Institute of Hydrology has recently published four new titles in the IH Report series:

Nant-y-Moch Grassland Improvement Study by A.M. Roberts, J.A. Hudson and G. Roberts. IH Report 104. Price £7.00

Estimation of Actual Evapotranspiration in Malawi by A.N. Mandeville and C.H. Batchelor. IH Report 110. Price £7.00

A Review of Design Flood Estimation using the FSR Rainfall-Runoff Method by D.B. Boorman, M.C. Acreman and J.C. Packman. IH Report 111. Price £9.00

The Telemetry of Hydrological Data by Satellite by I.C. Strangeways. IH Report 112. Price £7.00

These reports are available from the Librarian, Institute of Hydrology, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB.

UK Catchment Research Register

The Natural Environment Research Council is assembling a computer-based register of all the catchment research that its own Institutes and Units are carrying out. This is well under way for completion by June 1991, when it will be available to any interested party.

Those on the working group would like to see research of this type which is being undertaken by universities/polytechnics and other UK research bodies being added to the register as well.

If you are responsible for a catchment project in any environmental discipline and are willing to complete a simple questionnaire will you please contact either **Dr Keith Bull** at the Institute of Terrestrial Ecology, Abbots Ripton, Cambridgeshire PE17 2LS or **Frank M. Law** at the Institute of Hydrology, Crowmarsh Gifford, Wallingford, OX10 8BB.

Should you have already let the Institute know of your recent work for the forthcoming NERC publication Hydrological Research in the UK 1986-90 you need take no further action. The level of research intensity is not important; the only requirement is that the focus of the work should be at the topographic catchment scale and be aimed at knowledge of some catchment-scale process (i.e. reach/plot and regional work is not being targetted on this occasion).

The objective of the register is to increase awareness of work already completed and to encourage science community research in strength at catchments with complementary datasets.

Frank Law
Wallingford

BOOKS

Climate Change and Water

Conference of Climate and Water, The Academy of Finland, 1989, WMO, 2 vols, 520pp and 393pp, paperback.

Despite the broad title, this collection of papers from the WMO Helsinki conference of September 1989 essentially focuses on the more restricted topic of the impact of climate change, especially future global warming, on water resources in Europe. It is argued that this emphasis is justifiable given the rich database in Europe and the fact that resources are already under stress.

The books are evidence of the increasing interest amongst hydrologists in the climate forcing factor and the heightened profile of global warming, both of which grew apace during the 1980s. In contrast, in the early 1970s few hydrologists outside the Soviet Union were prepared to consider the impact of climate change. Indeed, most meteorologists were also inclined to see variability rather than change in the instrumental record.

It is therefore fitting that the doyen of global water balance and climate change, M.I. Budyko of Leningrad Hydrological Institute, should have presented the first keynote paper. This said, I have to confess that it is a disappointment and seems only to emphasise the isolation of Soviet science. The lack of modern super-computers and of any real familiarity with GCMs is all too evident and it is regrettable that Budyko proceeds to make a virtue of necessity by strongly advocating the advantages of using palaeoclimatic analogues in preference.

Even so, he maintains that only the 1980s warming can give a clear forecast of trends in the near future! And he is at pains to tell us that he correctly calculated global warming from 1970 to 1989 to within 10%, 20 years ago. He also tells us that orbital forcing "affects temperature insignificantly" and yet begs the question as to what caused Tertiary and Quaternary fluctuations of CO_2 that apparently affected it more. Surely the biosphere and the oceans were involved, but were they not responding to external triggers? (The record is eventually put right by Kuusisto on page 316, in his excellent review on snow and ice - that natural greenhouse gases are amplifiers of shifts of astronomical origin.)

Fortunately, Budyko's views are not shared by the second keynote speaker, Wilfred Bach, who presents an informed and well balanced overview. Bach displays a clear understanding of the structure, validation and true limitations of GCMs, presenting a useful summary of the characteristics of 12 models. He also states at the outset that he will only consider changes on a scale of 100 years or more to avoid the noise introduced by climatic variability. Bach gives a good summary of likely impacts in Europe.

The rest of Volume 1 is devoted to two principal topics: (1) current understanding of global climate, its variability and the potential for change; (2) the effects of climatic variability and change on aquatic environments and the hydrological cycle. By far the largest body of papers (14) is that concerned with precipitation and evapotranspiration patterns and these include some very useful national and regional detail for Europe.

A further nine papers are devoted to impacts on freshwater bodies. The remainder are divided between soil moisture (6), snow and ice (5), groundwater (3) and the ocean (2). Many of the papers are simply concerned with searching for trends in the instrumental record, some revealing no trends, e.g. in ice breakup dates (Kajander) and groundwater (Soveri *et al.*) in Finland, temperature in Hungary (Winter), oddly juxtaposed with papers that do show trends, e.g. river flow in Finland (Hyvarinen *et al.*), groundwater in South West Scandinavia and Illinois, and in a 450 year reconstruction for the upper Rhine (Schadler). One of the best experimental designs is described by D.N. Collins of Manchester, showing relative sensitivities to temperature and precipitation amongst basins with high to low levels of glacierisation on the Swiss Rhone.

Liebscher provides a model keynote review on freshwater bodies, including 72 references, and consideration of impacts on navigation, hydropower and thermal cooling waters, amongst others. Finally, Nigel Arnell and Nick Reynard present their early results from using hydrological models to simulate impacts on monthly river flows in Britain, of which perhaps the most alarming is runoff amplifying rainfall shifts up to threefold in South East England. The apparent aggravation of the NW-SE resource gradient in Britain is likely to be exacerbated by uneven regional increases in demand. The only salvation is that basins with greater groundwater storage may benefit during summer from higher winter rains.

Volume 2 is devoted to studies of (1) impacts on water-related socio-economic activities and (2) policy options at national, regional and international level in response to physical and biological impacts. The fact that Volume 2 is only three-quarters the size of Volume 1 partly reflects the relative amount of research thus far committed to impacts and policy.

However, one might have expected better representation in a few aspects if this had been an editor driven collection. This is especially so in the sections on water management problems and changing flood potential, each of which comprises one paper only, by the respective keynote speakers. Fortunately, both papers, by I.A. Shiklomanov and Franz Mobilis respectively, are useful summaries, the first giving interesting detail on the effects on the Volga and flows in southern European USSR, the second offering a sound review of current knowledge and a guide to where work is needed. The largest sections are on the terrestrial environment and on urban and industrial water supply (5 papers each), with sections on the aquatic environment, the coastal zone, energy and irrigation and land drainage each comprising 3 papers.

The volume begins with one of the best keynote papers, a survey of methods of estimating impacts on surface water

environments by Max Beran. Beran reviews information sources on the climate sensitivity of water quality, ecology and health aspects of global warming, noting the possibility of increased persistence of bacteria and protozoa, and of imported human and animal diseases. He also neatly presents the argument that, although uncertainty on both the magnitude and direction of change will remain for some time, this should not delay impact studies. There is a clear need for sensitivity tests and for developing impact models that will be ready once better climatological predictions become available. Beran outlines the main areas in which impact studies must be encouraged, including plankton, the tundra and disease. Amongst the 25 papers in this volume, I found particular interest in: (1) the paper on impact on the British coastal zone by Coker *et al.*, which outlines a methodology for assessing economic impacts of storm surges; (2) Frank Law's paper identifying the climate-sensitive segment of British reservoir yield; and (3) Niemczynowicz's use of the SWMM model for impacts on Swedish sewerage systems.

As usual in a collection of conference proceedings, there is considerable variability in the quality, length and value of individual contributions, with texts varying from barely 3 pages to over 30. Some of the East European and non-European contributions are of little value; some seem hardly related to climatic change (Kerenyi's). It would also help the reader if the editors had identified keynote papers and sections in the text as well as the Contents.

Nevertheless, this is a start, and as a genuine guide to the state of the art, it has few contenders.

J.A.A. Jones
Aberystwyth

Flood frequency analysis

Statistical distributions for flood frequency analysis. C. Cunnane. 1989. Operational Hydrology Report No. 33, World Meteorological Organization, Geneva.

Here is a slim guide for those navigating the perilous waters of return-period estimation. It charts a careful course around the positions of the major protagonists in a field where favoured approaches are stoutly defended but where minor differences of technique have potentially overwhelming consequences.

Dr Cunnane has taken his efforts well beyond the simple brief of giving guidance on the merits and selection of distribution types for flood frequency analysis. He lays bare many of the factors that make flood estimation far from prescriptive. Whether giving authoritative judgement (e.g. on estimation methods) or marshalling and refereeing the thoughts of others (e.g. on how to 'regionalize'), the report has many plusses for the hydrological researcher. He has digested a large literature to review flood frequency analysis clearly and economically. Indeed, the coverage is wider than the title of the report suggests since it includes distribution-free methods and of course all estimation methods are candidates for extremes other than floods.

Part of the report consists of a tabulation of the methods routinely and not-so-routinely used around the world for estimating extremes of flow and of rainfall: thus it updates an earlier WMO survey of flood and rainfall frequency estimation procedures. This is a useful source of information about national organisations. The list is inevitably incomplete and notable omissions lie in France, Italy and South Africa.

The major part of this report, and the main purpose behind it, is a reasonably detailed summary of useful data-analysis techniques and of the published results, comparing such techniques under different conditions. While the peaks-over-thresholds methods are included, the main emphasis is on the use of annual maxima data and, in particular, on the use of information combined across a number of sites (i.e. regionalisation).

The fundamental questions concerning the choice of distribution are seen to revolve around the numbers of parameters, and thus the flexibility, within each family of distributions, and around the amount of data available, possibly by transfer via regionalisation. Suppose that you are in the fortunate position of having 30 or so years of record from which to estimate the 50-year flood but no regional analysis to refer to. The author's advice is to think twice before shunning a 2-parameter distribution (such as the EV1) and reaching for the greater flexibility (but more variable quantile estimates!) of a 3-parameter distribution (such as the GEV). This is one of a number of areas in which Dr Cunnane points out that Flood Studies Report recommendations, while never implicitly wrong, were "good advice at the time" rather than immutable truths.

The technical side of the report is rounded out by the inclusion of complete prescriptions for selected estimation techniques, where these have been shown to perform well in the trials of performances reported.

Overall this report provides a comprehensive review of research into flood frequency estimation up to about 1986, the references tailing off thereafter. Whole new families of estimation techniques have been concocted since then, but nothing which overturns the advice given here. However, one important topic appearing too late for inclusion is the use of more than one large value each year, as in the methods proposed by Tawn (1988): this approach can provide a useful bridge between the annual-maxima and peaks-over-threshold approaches which otherwise seem incommensurable.

While the report is a delight for the specialist in technicalities, the conclusions are inevitably less sympathetic to the practitioner's needs. If one message comes through strongly it is that the research of the last ten to fifteen years has revealed a better understanding of the difficulties of flood frequency analysis but little concensus on their treatment. The author concludes that most practical flood estimation problems require a combined 'at site' and regional approach: this effectively puts the topic beyond the reach of many. The practitioner can follow this guidance only if a detailed regional or national study is available, or he/she is prepared to take such a study on. While regional flood frequency analyses have been carried out for many parts of the globe, few will satisfy the criteria that Dr Cunnane has set down.

There is a certain bluntness in the text which will doubtless attract criticism in the United States, if only for exposing the conflicting views of researchers and practitioners there.

The former are perhaps treated over-kindly by the author: an illustration is that he recites, beyond its worth, Hosking and Wallis's frequently quoted assurance that regional PWM methods are not seriously affected by spatial interdependence.

The writing and notation are generally clear, and the appendices ensure that details are amplified and illustrated without intrusion. The report has its share of typographical errors and inconsistencies, but not, it seems, to any serious consequence. The appearance and layout are typical of the new-style WMO reports; the lively cover is particularly welcome and amplifies the otherwise subdued message that graphical display of extreme value data is seldom wasted.

Reference: Tawn, J.A. (1988) An extreme-value theory model for dependent observations. *J. Hydrol.*, 101: 227-250.

Duncan Reed and David Jones
Institute of Hydrology

Cost-benefit techniques

Cost-Benefit Assessment Techniques and User Requirements for Hydrological Data, WMO Report No 32, Geneva 1990.

On first glance at the title of this publication the reader may gain the impression that the report deals exclusively with the cost-benefit of hydrological data. However, the title may be misleading: Parts A and B address the importance of hydrological data and describe some user requirements, while Part C alone investigates cost-benefit assessment techniques. The information in Parts A and B has, for the most part, already been covered in other publications and it is therefore a pity that it was not seen fit to produce Part C as a separate report which the subject certainly warrants.

As it stands, Part C falls short of supplying sufficient guidance to users who wish to assess the benefit-cost of hydrological data. It is little help to suggest that "it is difficult to provide hydrologists with comprehensive guidance". Vast sums of money are being spent annually on the acquisition of hydrological data. In the UK, for example, a study has estimated the replacement value of the streamflow network alone at £112 million and the annual revenue and capital cost of the network has been assessed at some £10 million, giving an annual average cost per network station of over £6000. It is therefore important to be able to make an economic assessment of the value - if any - accruing from this substantial investment.

The report does not give much help in this direction; overall, the part on benefit-cost analysis seems dated. The section begins by noting that WMO organised a Workshop in 1982 to assess the state of the art of benefit-cost analysis applied to hydrological data. The result is that no literature more recent than 1982 is cited and important areas of research are therefore omitted.

Moreover, the section would be clearer if it started with a clear theoretical statement defining the evaluation problem. This would note that economics is always concerned with the comparison of a 'with' to a 'without' condition. Hence, it is crucial to define what these 'with' and 'without' conditions would be: abolition of the whole network, the value of an additional year of record, changes in location, changes in number of gauges, or whatever.

Further, the economic value of the hydrological data is the information value of those data in the decisions to which they are applied: the increase in the value of output for constant resource inputs or the decrease in inputs for constant output that can be achieved compared to that for the 'without' condition. Hence, the economic evaluation of data is potentially a classic example of statistical decision theory based upon Bayesian Theory.

It should also be noted that unless the objective of the decision to which hydrological

data are to be applied is itself economic efficiency, the economic value of the hydrological data as applied to that decision will be zero.

Most of this fundamental theory is hidden away in the Workshop's conclusions, but it could be set out more coherently. Some parts of the text could also be clearer. The discussion on p 76, on postponing a scheme until additional hydrological information is gained, is somewhat confused, and the term 'expected expected opportunity loss (XXOL)', used in the text, is non-standard terminology.

The recent benefit-cost study of the UK streamflow network referred to above estimated the annual benefits at £21 million, giving an upper band benefit-cost ratio of 2. Streamflow is about 70% of the total annual costs of all hydrological measurements in the UK and streamflow and other hydrological data should therefore be addressed separately in assessing benefit-cost ratios.

R.G. Herschy
Reading

Wells and boreholes

Handbook of Groundwater Development, Roscoe Moss Company, (Los Angeles) John Wiley & Sons, 1990, 493pp, £70.50, hardback.

The first impression of this book is of a large and impressively produced volume. It is a collection of 20 chapters by various authors who are mentioned in the 'Acknowledgements' but not listed clearly. Several contributions are attributed to the Roscoe Moss Company which has 'over 80 years of drilling experience'.

The contents of the book are not obvious from the title. It is divided into three sections: Water in the Ground; Exploitation; Management and Use. These headings do not really inform the reader that it is a book about wells and boreholes and techniques of drilling, developing and exploiting the boreholes. Even the first section is really an introduction to wells and boreholes rather than groundwater hydrology.

The real difficulty is in assessing the intended readership of the book. It is not a book for the expert nor does it provide the general reader with all the information required to become an 'expert'. The level at which the chapters are written is extremely variable. Most start at the very beginning, which can be irritating - statements such as 'the pump should be set below the anticipated pumping level' and 'there should be enough fuel on site to complete the test' are typical.

Some chapters do not progress beyond simple description while several go into very considerable and useful detail. Most notable of these are contributions on Stresses on Well Casing and Screen, Water Well Cementing and Well and Aquifer Evaluation from Pumping Tests. On the other hand, the chapter on Geophysical Borehole Logging is very uneven, detailing resistivity logging and the spontaneous potential technique, where the author clearly has practical experience, and dismissing other techniques in a few paragraphs. The impression given is that the well developer should employ a professional geophysicist to do such things, which is not very helpful.

Groundwater modelling, including physical sand models, is dealt with in about 10 pages of text without more than skimming this important area.

There are 54 pages of rather *ad hoc* appendices including 'Sources of geohydrological data', which is short and based on the USA with a few international references; 'Groundwater regimes in the USA', which is very general; 'Design of an airlift pump', which is short and of little value, and one detailed tabular appendix on properties and standards for water well casing: this is highly appropriate to a 'Handbook', but is in such detail as to be out of balance with the rest of the book.

Overall, this is probably a useful volume for the bookshelf if one wants general background to water well or borehole installation and exploitation, but not one to leave its mark as a vital component of the library.

Brian Smith
Wantage

History of WMO

Forty Years of Progress and Achievement - A Historical Review of the WMO edited by Sir Arthur Davies, WMO 721, SFr90.

This impressive hardbound, gold-blocked book of just over 200 A4 size pages was produced, as the title states, to mark the 40th anniversary of the World Meteorological Organisation.

It was written by the six members of the WMO 'history group' under the chairmanship of Sir Arthur Davies who was the Secretary General of the WMO from 1956-79.

It is clearly presented on heavy duty paper with extensive, but regrettably only black-and-white, photographs throughout. After an historical introduction to the formation of the WMO, chapters follow on all the main areas of its work. These include: The World Weather Watch Programme; Instruments and methods of observation; Cyclone, marine and oceanographic programmes; Aeronautical and agricultural meteorology; Hydrology and water resources; Research, environment, climate, educational and technical programmes; Regional programmes and collaboration with the United nations system; The future of the WMO.

In addition there are a rather dry 30 pages detailing WMO conventions and staff etc. together with a very useful three pages of WMO abbreviations.

The Hydrology and Water Resources chapter is one of the most detailed. It gives a very full background to the development of this area in the WMO since its foundation, together with sections on most relevant topics including the International Hydrological Decade, World Climate Programme for Water and HOMS.

Overall the book makes interesting background reading for those who have worked or are working on projects associated with the WMO, and would provide a good first introduction to those just starting on such involvements. As such it would be a useful book for libraries to keep in their general reference section.

However, its very broad nature, lack of detailed index, and price would not make it a popular buy for the working scientist.

H.R. Oliver
Wallingford

Vegetation and landscape

Vegetation and Erosion. Thornes J.B. (ed). 1990 . John Wiley and Sons, Chichester, £70.

This edited volume containing some twenty-nine papers is the product of a British Geomorphological Group meeting in 1988. It is a highly diverse collection of pieces of current research from geomorphologists for whom vegetation is an important landscape variable, although not necessarily the central focus of study.

Following contextual chapters from John Thornes and from Heather Viles, reviewing the principal biological processes which affect geomorphology, the contributions from field, laboratory and mathematical modelling studies are wide ranging: Soil erosion in semi-arid, temperate and tropical environments; The value of geotextiles to retard or control erosion; Deposition in marsh environments and vegetation response; Vegetation response to channel change and as a protector of river bank against erosion; The effect of vegetation on the chemistry of runoff, infiltration patters and overland flow processes; Wind erosion rates simulated for a range of crop covers; The impact of fire on temperate heathlands and semi-arid soils, and The dynamic response of vegetation in desert dune environments as a stabiliser, point for accretion and determinant of dune morphology.

Perhaps the paradox of these papers is that vegetation response to environmental change or disturbance by man is frequently very slow, and often awkward to monitor because of this slow variation, while current research tends to emphasise short-term process investigations. There is a tendency, even in this volume, to acknowledge that the role of vegetation is not changing dynamically.

Clearly there is plenty of excellent, active research on plant interrelationships with the landscape at small scales. Ecosystem and landform development at a more regional scale is still a neglected area.

P.E. Kneale
Leeds University

NEWS FROM MEMBERS

PROFESSOR WALLING RECEIVES 1990 VOLLENWEIDER AWARD

Professor Des Walling recently received the Vollenweider Award for 1990. The award is granted annually by the Canadian National Water Research Institute and Environment Canada for global contributions to the advancement of the aquatic sciences.

He was presented with the award at the Canada Centre for Inland Waters in Burlington, Ontario, where he delivered a lecture entitled '*The wearing away of the land: global and local perspectives*'.

UNCED Research Fellowships

The United Nations Conference on Environment and Development, to be held in Brazil in June 1992, will focus on sustainable development, covering issues relating to meteorology and operational hydrology, including protection of freshwater resources.

The UNCED Secretariat intends to recruit Research Fellows for periods of up to two years to work in areas relevant to the conference agenda. Approximately 20 young candidates holding Masters or Doctors degrees in relevant subjects (including hydrology and meteorology) will be appointed, at a remuneration of about $4000 per month.

Application forms may be obtained from the Editor, from Bruce Callander at the UK Meteorological Office or from UNCED Secretariat and should be returned to the Office of the Secretary-General, United Nations Conference on Environment and Development, B.P. 80, CH-1231 Conches, Geneva, Switzerland, Fax: +41 22 789 35 36.

FORTHCOMING EVENTS

Meetings

IUGG / IAHS GENERAL ASSEMBLY, VIENNA, AUGUST 1991

Those attending the IAHS General Assembly in Vienna and who have had either oral or poster papers accepted for inclusion in the programme are reminded that **abstracts must be submitted** to the appropriate Workshop or Symposium convenor and to the Local Organising Committee by a revised deadline of **March 1, 1991**. The address is: Local Organising Committee, IAHS 1991, c/o Dr Franz Nobilis, Hydrographisches Zentralburo, Marxergasse 2, A-1030 Vienna, Austria.

These abstracts will be included in the IUGG Abstract Volumes which will be distributed to participants at the Assembly. Instructions for preparation of camera-ready abstracts should already have been circulated by Symposium and Workshop convenors.

Scottish Hydraulics Study Group
One-day Seminar on
RIVER & FLOOD PLAIN MANAGEMENT
22 March 1991
The Albany Hotel, Glasgow

Papers will cover environmental aspects of river and flood plain management, engineering design of two-stage channels and numerical modelling of rivers and flood plains.

Further details from Dr G.. Pender, Department of Civil Engineering, University of Glasgow, Glasgow G12 8LT (Tel: 041-339 8855, ext 5529).

BHS / Scottish Hydrological Group
HYDROLOGY & WATER POWER DEVELOPMENT
14 June 1991
The Albany Hotel, Glasgow

As a result of current energy policy, particularly in England Wales, there has been a revival of interest in hydro-power development on the medium to smallscale. This meeting will mainly consider the hydrological aspects of such developments but also turbine types, the passage of fish and general environemntal effects.

Further information may be obtained from Dr J.G. Herbertson, Dept of Civil Engineering, University of Glasgow, Glasgow G12 8LT (Tel: 041-339 8855, ext 5215).

International
Hydrology and Water Resources
Symposium 1991
2 - 4 October 1991
Hyatt Regency Hotel, Perth, Australia

The Institution of Engineers, Australia is sponsoring this symposium under the title *"Challenges for Sustainable Development"*; the co-sponsors are UNESCO, WMO and IAHS.

Papers will be presented on topics covering hydrology and water resources management. Issues relating land and water resources management to the increasing pressures on our environment will be at the forefront. Workshops are being arranged for the day before the symposium, **1 October 1991**.

Enquiries should be addressed to The Conference Manager at The Institution of Engineers, Australia, 11 National Circuit, Barton ACT, 2600 Australia; Fax: +61 (06) 270 6530.

Diary

113th March 1991
Royal Society Bakerian Lecture
Dr J T Houghton, "The predictability of weather and climate".
Time: 5.30 pm (tea at 5 pm)
Venue: 6 Carlton House Terrace, London
(also to be given at Belfast on *9th April* and at Edinburgh on *25th April*: details from the Royal Society, tel. 071 839 5561, extn 278)

21st March 1991
Seminar: "Introduction to GIS"
Hydraulics Research, Wallingford, OX10 8BA
For details of this and all HR seminars, contact Fiona Farnsworth, 0491 35381.

15th-17th April 1991
2nd Postgraduate Hydrology Symposium
Polytechnic South-West
Contact: Peter Sims, Dept. of Geological Sciences, Polytechnic South-West, Drake Circus, Plymouth, Devon, PL4 8AA.

16th April 1991
BHS Southern Section
"Water Quality in Agricultural Catchments"
Venue: FDEU, Cambridge
All day meeting, starting at 10.30 am.
Contact: Howard Wheater, Imperial College, 071 589 5111.

30th April - 2nd May 1991
IWEM 91 Conference
"Water and the Environment"
Venue: International Convention Centre, Birmingham
Further details in *Circulation 26* and from IWEM, 15 John Street, London WC1N 2EB, Tel.: 071 831 3110, Fax: 071 405 4967.

10th - 12th May 1991
BGRG Spring Field Meeting
"Geomorphology and Sedimentology of Lakes and Reservoirs"
Venue: University of St Andrews
Contact: John McManus and Robert Duck, Dept of Geography and Geology, University of St Andrews, St Andrews, Fife, KY16 9ST, Tel.: 0334 76161 extn 8425/7.

21st May 1991
BHS Southern Section
"Operation Experience with FRONTIERS Rainfall Forecasts"
Venue: Dept of Civil Engineering, Imperial College, London SW7 2BU
Contact: Howard Wheater (see above).

11th - 14th June 1991
Institution of Water Officers
Conference and Exhibition
Venue: Eastbourne, Sussex
Details: David McConnell, Eurocom (UK) Ltd, 12 Summerhill Terrace, Newcastle upon Tyne, NE4 6EB.

Copy Deadline for Issue No. 30
5th April 1991

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