THE GSI GROUNDWATER NEWSLETTER

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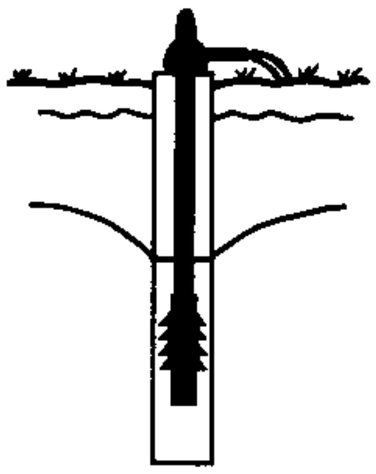

NUACHTÁN SCREAMHUISCE SGÉ

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Published by the Geological Survey of Ireland.
Beggars Bush, Haddington Rd.,
Dublin 4. ☎ (01) 609511

Edited by: Donal Daly.

Foilsithe ag an Suirbhéireachta Gheolaíochta Éireann.
Tor an Bhacaigh, Bóthar Hadington,
Baile Átha Cliath 4. ☎ (01) 609511

No. 7. March, 1988.

IN THIS ISSUE

In introducing this issue of the **Newsletter** I can only begin with the most significant event in Irish hydrogeology since our last issue went to press - the sad death on December 31 of **Dr. David Burdon,** doyen of Irish Hydrogeology, our most distinguished colleague, friend, advisor and teacher, citizen of the world and parishioner of Buttevant. We shall not see his like again. His **obituary** is on page 12.

I like to think that David would have enjoyed the strong input into this issue from a variety of educational institutions, including both our oldest University (Trinity) and our youngest (Ulster), as well as Sligo RTC and Navan Community College, from which we welcome our youngest contributor (so far!) in Siobhan Lanigan-O'Keefe, the **Aer Lingus Young Scientist of the Year for 1988** (page 10). Siobhan's topic also recalls David Burdon's own enthusiasm for **geothermal studies.**

Our subject matter ranges widely. In our first item, Charles Essery outlines the interesting story of an **arterial drainage scheme in Co. Antrim** which has had important and unforeseen effects on the local groundwater resources. He stresses the need for prior studies with a strong hydrogeological component (page 2). On page 4 Kieran O'Dwyer has news of **high-yielding wells in the Meath-Monaghan region.**

On **groundwater pollution** we have items from Hubert Henry on **bacterial pollution** (page 6), from Paul Dowding on the **significantce of fatty acids as pollution indicators** (page 9), and advice from Michael Gardiner on **slurry spreading** (page 5). On page 7 our Editor continues his series on **septic tanks and groundwater,** and on page 8 David Drew presents some interesting observations on the little-known topic of **dissolved oxygen in groundwater.**

So there you are - something for everyone! Now read on.

Geoff Wright, Geological Survey of Ireland.

P.S. See in you in Portlaoise - don't miss it! (page 11).

GROUNDWATER DEVELOPMENT

Land Drainage - Its Impact on a Glacial Aquifer

Few of us can be unaware of the widespread nature of land drainage in Ireland. No major rivers have avoided its effects and the visual surface impact is all too apparent. However few scientific studies have been made of the impact of large arterial drainage schemes. Here, I would like to indicate some of the initial groundwater findings of one such study.

The River Maine, Co. Antrim is currently undergoing major arterial drainage which includes extensive downstream flood protection. In the spring of 1984 the engineering works entered an established monitored catchment. This catchment, which is over 200 km^2 in size, includes large alluvial and bog floodplain deposits. Since 1978 continuous river gauging at the outlet and on four sub-catchments has been maintained, along with rainfall and evapotranspiration measurements. In addition, groundwater levels have been monitored in the shallow floodplain, in the underlying (discontinuous) sand and gravel aquifer (data from the Geological Survey of Northern Ireland) and in the remainder of the catchment (using disused farm wells). The main aim of this study was to monitor the overall surface water balance over varying timescales and compare these with the measured groundwater changes. Having obtained five years pre-drainage and three years post-drainage data (up to October 1986) some dramatic effects have been noticed in the water balance studies.

The yearly water balance for the floodplain catchment ($67km^2$) now indicates that the stream discharge in the post-drainage years is substantially in excess of the rainfall input! Effectively stream discharge has doubled in these years and shows no signs of decreasing. So where does this water come from? The aim of land drainage is to lower water tables and arterial drainage represents the first stage by offering a lower outfall for current and future field drains. However, examination of the farm well observations in the bedrock showed no significant drawdown in the post-drainage period. Equally, the drawdown in the shallow floodplain transects was limited to the wells at the end of the transects (typically within 20 metres of the river). Owing to the low hydraulic conductivities of the floodplain materials (mainly boulder clays and peat), this limited drawdown could not be responsible for the large, consistent increase in stream discharge.

The only other source for this excess discharge had to be the underlying sand and gravel aquifer, and indeed several of the piezometers close to the river works show signs of drawdown. Examination of the excavated river banks indicate the probable cause. Along the length of the newly deepened and straightened channel, the stratigraphy of the floodplain deposits is clearly defined. The upper layer consists of a typical boulder clay capped with peat and alluvial deposits. However, at the level of the pre-drainage river bed (typically 1.5 metres) there is a homogeneous fine-grained layer approximately 30cm thick. This in turn caps a coarse heterogeneous glacial deposit in which the new river bed now flows. Before drainage, continuity between the river and this aquifer appears to have been hindered by the finer grained layer (believed to be lacustrine), but now through the efforts of the drainage engineers the river has direct contact with the sand and gravel aquifer. The doubling of stream discharge represents a mean equivalent depth over the catchment of 0.565m per year. The exact extent of continuity of the underlying aquifer is unknown, but assuming the aquifer area to be half that of the catchment a conservative estimate suggests that 52,079m^3/d is being discharged by the aquifer. Pumping from the aquifer wells rarely exceeds 10,000m^3/d (peak summer pumping). As this aquifer is used to supply water to the surrounding towns, such losses should concern not only environmental scientists, but also those involved in the water supply industry.

The impact of the River Maine arterial drainage scheme has exceeded the expected changes normally associated with streamflow characteristics. The deepening of the river channel in this case has interfered with the groundwater regime of the catchment. What is particularly worrying about this case is that no detailed study of the hydrogeology of the area was considered in the planning or execution of the arterial drainage scheme. Monitoring of the River Maine continues and it is hoped this will indicate whether the increased stream discharge is a permanent or temporary feature. It will also be interesting to determine if the drawdown in the aquifer will continue or be counterbalanced by recharge. I would be interested if any readers have come across other cases similar to this.

Charles Essery, Department of Computing Science, University of Ulster at Jordanstown.

Successful Wells at Slane and Smithboro.

The undeveloped nature of Irish groundwater resources was well documented in two recent local authority water well drilling projects in counties Meath and Monaghan. Production wells were to be drilled at Slane and Smithboro and while the proposed well designs were based on existing drill hole data the finished wells differed significantly from the initial specifications.

At Slane, a production well was to be drilled into the Boyne floodplain just west of Slane bridge where previous trial wells had indicated a 20m thick sand and gravel aquifer, with average well yields in excess of 1,000m^3/day. However, the drilling of the production well enabled an investigation of the underlying limestone bedrock which proved to be even more productive than the overlying sand and gravel aquifer. The Slane production well was completed in the limestone bedrock and was tested to a yield of 2,000m^3/day.

The Smithboro well in Co. Monaghan was the reverse of the situation at Slane with the new well designed to replace a trial well located in the limestone bedrock. However, a very productive gravel aquifer was encountered above the limestone bedrock and the well was finished in this formation to avail of the increased yield. The Smithboro well was tested to a yield of over 1,500 m^3/day.

These two projects highlight the variability of Irish geological conditions, the abundance of groundwater here and the need to investigate both the glacial deposits and bedrock in any hydrogeological study.

Kieran O'Dwyer, K.T. Cullen, Hydrogeological & Environmental Services.

LOCAL NEWS

Institution of Water and Environmental Management

John Walsh of E.G. Pettit & Company has written concerning Geoff Wright's article in Issue No. 6 of the **Newsletter,** to tell me that the Institution of Water Engineers and Scientists (IWES) has amalgamated with the Institution of Public Health Engineers (IPHE) and the Institute of Water Pollution Control (IWPC) to form the Institution of Water and Environmental Management (IWEM), based at 15 John Street, London WC1N 2EB. There is an active Irish branch, chaired by Mr. L. Kilmartin, D.O.E. and the secretary is Michael Fitzpatrick, of John B. Barry and Partners, Dublin.

Donal Daly, Geological Survey of Ireland.

GROUNDWATER QUALITY AND POLLUTION

Safe Farm Slurry Disposal - Some Considerations

Many factors influence the safe disposal of farm slurry. Amongst these are (1) weather and (2) soil type.

Wet weather immediately after spreading can cause run-off. A chart showing the probability of dry days occurring at different times of the year in different regions can therefore be useful. More important is to try to spread when there is a soil moisture deficit. Then the liquid slurry can be absorbed into the soil and will not tend to run-off.

A soil moisture deficit occurs when potential evapotranspiration exceeds cumulative precipitation. It usually starts in April and ends in September or October. The country can be divided into four broad regions in this respect. These are (a) southeast, 105mm (b) midlands, 58mm (c) west, 20mm and (d) northwest, 2mm. With the exception of the northwest these deficits are sufficient to allow for the safe acceptance of normal slurry volumes.

But, for this, spreading would have to be within the period for that region when there is a soil moisture deficit. For the four above regions respectively these periods are (a) April through October (b) May through September (c) May through August (d) July only.

However the problem is more complex because of the soil type factor. Each individual soil type has a particular liquid acceptance potential. This depends mainly on its texture, slope and hydraulic conductivity. When the main soils of the country were grouped on the basis of liquid acceptance potential it was found that 36% were very low, 19% moderate and 30% were high. The distribution of these different classes can serve as broad guidelines for the timing and volumes of slurry which can be safely spread. They can also be used as general guidelines for differences in storage requirements between regions.

Michael Gardiner, An Foras Talúntais.

(This item is a synopsis of a paper "Soil, site and climatic factors in slurry disposal" in the Irish Journal of Agricultural Research, vol. 25, 1986.)

The Contamination of Groundwater Supplies with Fecal Coliform Bacteria after Periods of Heavy Rainfall

In the last issue of the **GSI Groundwater Newsletter** David Drew pointed out that he had noticed a positive relationship between the number of Escherichia coli. isolated from groundwater supplies and increased rainfall. He enquired if this was usual and would not a dilution effect be expected?

Escherichia coli. is a non-motile bacterium incapable of self propulsion or movement in the soil. It is dependent on the percolation of the effluent in which it is suspended (septic tank effluent, animal slurries etc.) and rainfall percolation for its migration to groundwater. The two main mechanisms by which bacterial movement in soils is prevented are filtration and adsorption. The higher the cation exchange capacity (C.E.C.) and the finer the texture, the greater the amount of filtration and adsorption and thus the greater the degree of bacterial "fixation". As a result in all but the most sandy substrates fecal coliform movement is retarded to some extent. The bacteria remain "fixed" in the soil until they die-off. Recent experiments in Sligo R.T.C. have indicated that this can take much longer than has hitherto been observed and thus there is a build up of viable organisms in the soil. During periods of heavy or prolonged rainfall "flushing" of the fixed organisms takes place leading to their appearance in groundwater. Field research at the college on the movement of Escherichia coli. from septic tank disposal systems has shown that the number of these organisms isolated from soil samples collected down gradient of the system was over 10 times greater after periods of heavy rainfall than those detected during drier periods (see p. 6 of **The GSI Groundeater Newsletter,** No. 4, 1987).

The "flushing" effect has been noted by a number of authors including Patterson et al (1972) (pp43-47) and Bitton & Gerba (1983) (pp 181-197)

References:

1. Patterson, J.W., Minear, R.A. and Neoved, T.K. (1972) Septic Tanks and the Environment. Illinois Institute for Environmental Quality, Chicago, Illinois (98pp)
2. Gabriel Bitton & Charles P. Gerba (1983) Groundwater Pollution Microbiology, John Wiley & Sons (377pp)

Hubert Henry, Sligo R.T.C.

Septic Tanks and Groundwater Pollution: Remedies

1. Septic tank desludging: The septic tank should be emptied regularly - preferably once a year (IIRS, 1975)*. Many householders do not do this at present. Consequently, local authorities should consider providing a septic tank desludging service.

2. Soakage pits and percolation areas: Soakage pits should not be allowed for any new installation. Instead pipe distributions systems should be installed because they disperse the effluent over a relatively large area, close to the ground surface and therefore as far as possible above the bedrock and water table.

3. Depth to bedrock: If effluent enters directly into fissured rock, chemical attenuation is poor and there is minimal filtration of pathogenic microbes. There should be at least 1.0m of granular subsoil between the bottom of the pipe distribution system and the bedrock. Planning permission should not be given for sites where the rock, particularly limestone, is at or close to the surface, unless remedial measures are taken.

4. Depth to water table: An unsaturated zone considerably increases the attenuating capacity of subsoil. A minimum unsaturated zone of 1.0m thickness is recommended.

5. Site suitability tests: Percolation tests and water table tests, as recommended by IIRS (1975)*, are essential, yet many local authorities neither require nor enforce these tests.

The percolation test enables an assessment of the ability of the subsoil to accept and dispose of the effluent. There is usually too little consideration given to situations where the percolation rate is excessive i.e. where the value of "T" is less than 5 min/in. In this situation, which occurs in clean gravel or bedrock, the septic tank should not be allowed unless a lower permeability granular material is introduced beneath the percolation pipes.

* IIRS, 1975 Recommendations for septic tank drainage systems suitable for single houses. S.R. 6. 1975, 28pp.

(This contribution is the fifth in a series on septic tanks. If you have points to make, write to **The Newsletter.**

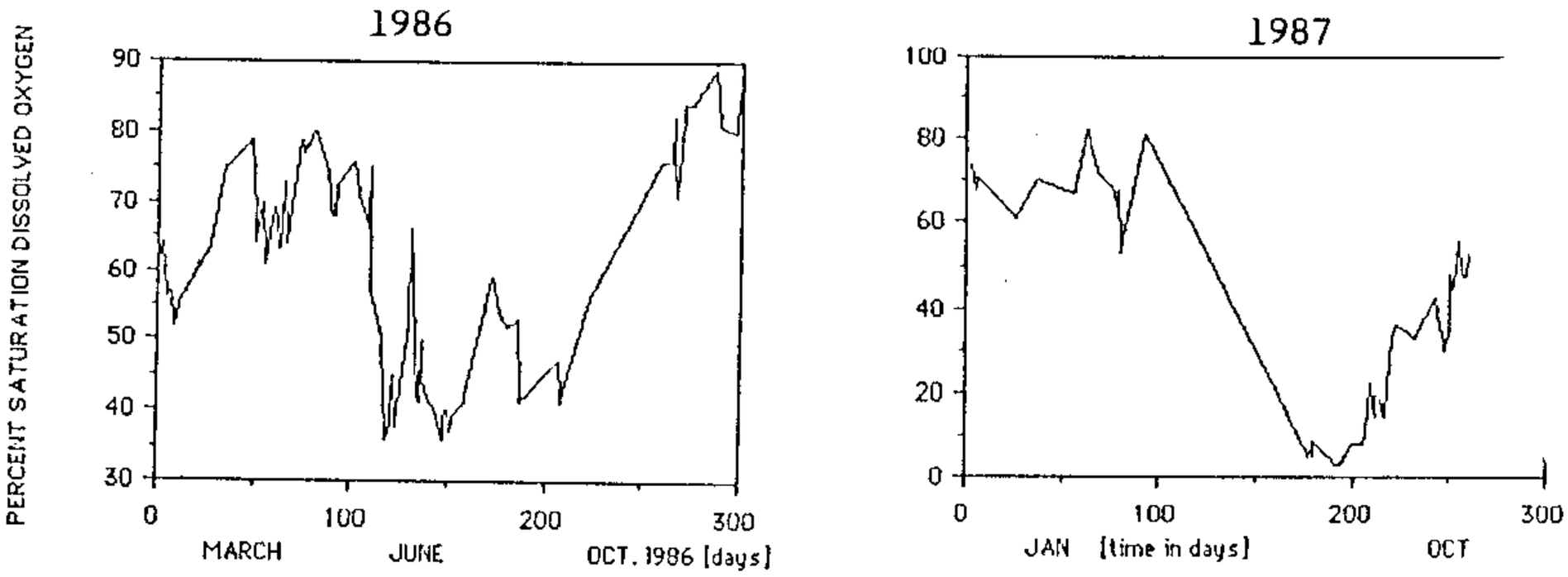
Donal Daly, Geological Survey of Ireland.

Dissolved Oxygen Concentrations in Groundwater

Comparatively little appears to have been written on dissolved oxygen (D.O.) values for groundwater (as against an abundance of information for rivers and lakes). Conventional wisdom indicates that values will be very low unless aquifer residence time is very "short" and little or no oxidisable matter is present.

Regular D.O. measurements over a two year period at a limestone spring in east Co. Galway used to supply a hatchery, showed remarkable fluctuations and provoked the author to undertake a mini-survey of oxygen levels in the surface and groundwaters in the area between the Clare River and Lough Corrib during the autumn of 1987.

The graphs below show D.O. % saturation for 1986 and 1987 at the hatchery spring and it is apparent that levels fluctuate widely (max. 70%, min. 3%) with an overall summer low and winter high.



Fluctuations also occur on a much shorter time scale (weeks or days) and there are considerable variations in absolute levels of D.O. between adjacent springs. The graph below shows D.O. levels at three springs which are similar in water chemistry and are fed by about 15% stream sink water and 85% diffuse recharge with minimum residence times of 2-5 days.

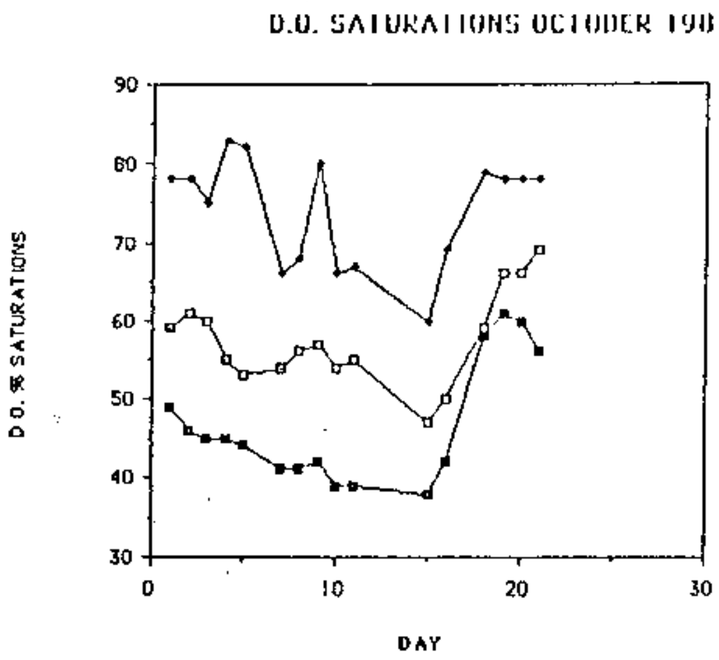
In order to expand the data set, D.O. measurements were made from the rivers in the area and a sample of springs and boreholes, during high flow conditions in October 1987. River waters were uniformly supersaturated whilst values from the five spring measurements were 69%, 64%, 84%, 53% and 95%. For the boreholes the values ranged from 29-64%.

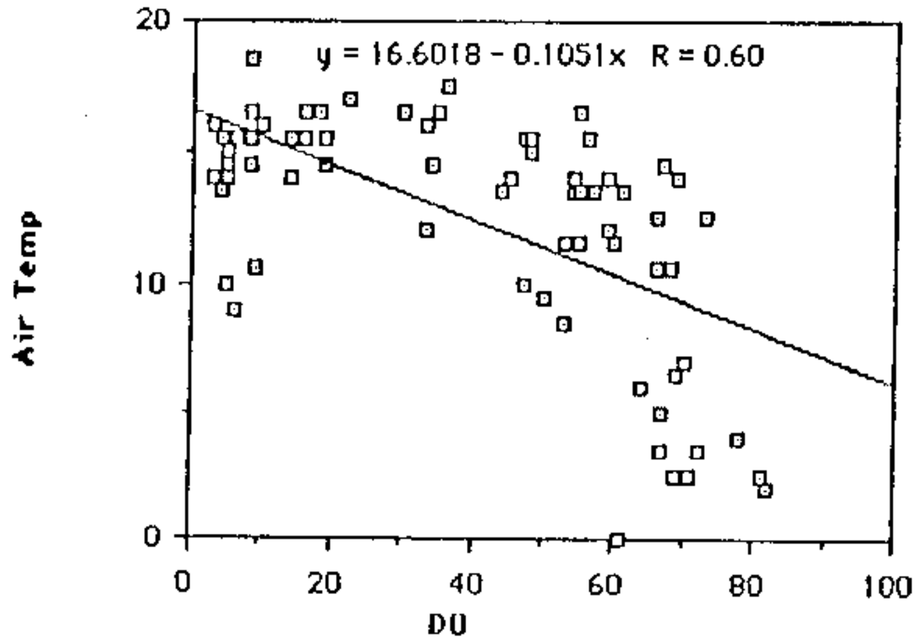
Possible explanations??

1. Variations with changes in water temperature - seemingly no correlation.

2. Variations with discharge - again no good correlation.
3. Variations with air temperature - yes, to an extent, especially when temperatures are lagged e.g. the graph below shows air temperature lagged fourteen days prior to D.O. data. If this is a real relationship presumably it is indirect (i.e. via biological activity,) rather than direct.

Any other data on D.O. levels in groundwater and/or explanations would be most welcome.





David Drew, Geography Department, T.C.D.

Fatty Acids as an Indicator of Silage Effluent Pollution

In response to the article in Issue No. 6 of the **Newsletter** on silage effluent as a source of groundwater pollution, I consider that fatty acids are <u>not</u> an absolute indicator of silage effluent pollution. Short chain fatty acids are formed by anaerobic degradation of cellulose and so would be constituents of groundwater pollution from digestion of cellulose in septic tanks. There may be information in the literature on fatty acid spectra in septic tank effluent and silage effluent which would be used in determining particular fatty acid indicators. However, silage is made in different ways and many farmers add inorganic acids to get around the poor formation of fatty acids in silage with a low sugar content. A single fatty acid spectrum for silage may no longer be appropriate to the Irish experience.

Paul Dowding, Environmental Sciences Unit, T.C.D.

ENERGY

Geothermal Study of the River Skane, Co. Meath

This investigation resulted from a previous project where I showed that the River Skane was always 1°C higher in temperature when compared with two other rivers.

I first examined an eight mile length of the river, using a simple manually operated digital thermometer, accurate to 0.1°C. I soon located an area in which a more detailed study was necessary. I had to take into consideration different factors that might have caused the heat rise. However, both a simple chemical and biological assay of this stretch of water showed no signs of pollution that might have contributed to the rise. Atmospheric conditions were also discounted, although slight seasonal fluctuations occurred.

Then I looked at the field beside the river. I needed an indication of where, if any, heat was radiating from the ground. Of course with such a small difference in water temperature, that of the ground was hardly to be noticed by the naked eye; so I came to use infra-red photography.

This showed an area of about 30 sq. feet, which on investigation with the thermometers showed a rise and fall in ground temperature.

From all this and relevant information, I deduced that the area is being influenced by a warm spring. As to whether the precise location of the spring can be found remains to be seen. However, it shows the possibility of discovering new warm springs in an area of high warm spring density (in relation to the rest of Ireland).

In the coming month, a more detailed chemical assay will be carried of the heated ground, with drilling to depths of about 3 metres to obtain ground and water temperatures. Hopefully, it will be possible to locate the spring or direction of its flow, if it undergoes lateral drainage.

Siobhan Lanigan-O'Keefe, Community College, Navan.*

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* Siobhan won the 1988 Aer Lingus Young Scientist of the Year Award for her geothermal study of the River Slane. This is the third year in a row that a groundwater project has won one of the major prizes. So congratulations Siobhan - we hope you enjoy your trip to the Nobel Prize Ceremonies.

Donal Daly, Geological Survey of Ireland.

I.A.H. NEWS

8th Annual IAH Groundwater Seminar at Portlaoise

This year's seminar, the highlight of the IAH calendar, will be held on Tuesday and Wednesday, 12th and 13th of April, at our usual venue, the Killeshin Hotel.

The seminar will be focussing its attention on the future - Tuesday's theme is "The Future of Groundwater Development", and our Keynote Speaker will be Glyn Jones, who runs the postgraduate (M.Sc.) course in Hydrogeology at University College London, the first of its kind in Britain and now in its 22nd year. In addition to his teaching and research work, Glyn is much in demand worldwide as a consultant, and we are very pleased that he is able to be with us.

Other speakers include Wexford's County Engineer, Phil Callery on "Groundwater for Public Supply", and other papers will deal with Group Scheme Supplies, 'New' Aquifers, the Future of Well Drilling, and Future Uses for Groundwater.

Wednesday's theme is also very much concerned with the future - "Groundwater in Environmental Impact Assessment" - with European Directive 85/337/EEC, which must be implemented by July 3 1988, very much in mind. The theme will be introduced by Gerry Walker of An Foras Forbartha and David Kelly of Eolas, and two Irish case studies will be presented.

We aim to make this year's seminar the best ever, with improved facilities for exhibitors, a new Poster Section, and better catering arrangements. So, at the same old price of £50 a head, we offer even better value! We know money is tight in 1988, but whatever else you cut, don't miss out on Portlaoise this year!

If you haven't received a circular, contact Breda Naughton at An Foras Forbatha or Geoff Wright at the GSI.

Geoff Wright, Geological Survey of Ireland.

Congratulations to Suzanne O'Sullivan, I.A.H. member, who was recently conferred with an M.Sc. in Environmental Sciences at Trinity College Dublin. As part of her work, Suzanne compiled a thesis on a study of "the effects of waste disposal sites on groundwater quality in Leinster".

Geoff Wright, Geological Survey of Ireland.

DAVID J. BURDON - AN OBITUARY

David Burdon was born in 1914 and educated at Clongowes Wood College, Dublin, University College Dublin (B.Sc. and B.E.), and Camborne School of Mines, Cornwall. After working in the Kolar Goldfield in South India for several years, he completed a Ph.D at Imperial College London, on "The Geology of the Southwestern Part of the Leinster Granite" (1949).

At this point in his life he began a career in Hydrogeology which was to bring him such great distinction, beginning in 1949 in Cyprus as water engineer and geologist to the administration. In 1952 he joined the U.N. Food and Agricultural Organisation (FAO) initially working in Syria and Jordan (1952-60), Greece (1960-63) and Egypt (1963-64), and later throughout the Middle East and Africa from FAO Headquarters in Rome.

In 1974 David Burdon retired from FAO, and returned to his family home, Rathclare House, in Buttevant, County Cork. For David this only meant a renewed phase of activity. From 1974 until his death in December 1987 he encompassed a multitude of activities - numerous consultancy tasks for FAO and other U.N. agencies, consultant to the GSI, director of Minerex Ltd., visiting lecturer and external examiner at several Irish and British Universities, combined with studies of local history around Buttevant, running the family farm and taking an active role in Parish affairs.

David was a founder member of the International Association of Hydrogeologists, which began at the 19th International Geological Congress at Algiers in 1952 and was made an Honorary Member in 1986. He helped found the Irish Group of IAH in 1976, served as President for seven years, and was a constant source of encouragement for all concerned with hydrogeology in Ireland. David was also a Fellow of the Geological Society, Member of the Institution of Mining and Metallurgy, and member of the Institution of Geologists, which in 1982 awarded him its Aberconway Medal.

A prolific writer, David was a world authority on groundwater resources especially in Karst areas, and in 1963 was awarded a D.Sc. by the National University of Ireland. But above all he will be remembered as a great encourager, rejoicing in discussion and debate. Many of us will also remember David as a family man, an entertaining and hospitable host, who always had time in his busy life for anyone wanting advice or comment upon some idea or draft report.

David's wife Katherine, who had shared his life at home and abroad for thirty-six years, died in 1986, a loss which dimmed but did not quench his enthusiasm for life. He continued his work almost until the end, visiting

Libya only a few weeks before his death. He passed away on New Year's Eve 1987, after a short illness, and we said farewell to him on a rainy January afternoon in the churchyard in Buttevant. At the requiem mass the Parish Priest reminded us how David insisted that he was a "citizen of the world". Indeed he was. We are the poorer for his passing.

To his daughter Barbara and his sons, David, Desmond, Andrew and Paul, and his sister Vaun, we offer our deepest sympathy.

Geoff Wright, Geological Survey of Ireland.

EDUCATION

Seminar in U.C.G. on "Applied Geophysics in Groundwater Investigations"

The U.C.G. Applied Geophysics Unit, in conjunction with the I.A.H., are presenting a one-day seminar on 25 March which will give an introduction to geophysical methods, case histories from Ireland and overseas and demonstrations. It will cost £2.00 (£1 for students) and is intended for engineers and geologists. For further information contact Kevin Barton or Andrew Brock Tel: (091) 24411. Registration is at 10.30 a.m.

Geophysics is now an essential tool in successful groundwater exploration and so this seminar will be well worth attending.

Donal Daly, Geological Survey of Ireland

Groundwater Pollution Course at Birmingham

A one week course, offering an introduction to sources and effects of pollution, investigation techniques, transport and chemical processes, modelling, prevention and remedies, will take place at the University of Birmingham on 18-22 April. For more information contact David Lerner, Department of Geological Sciences, University of Birmingham, P.O. Box 363, Birmingham B15 2TT. Tel. 032 414 6156.

NEWS FROM ABROAD

Spain

Under a new Spanish law, landowners can no longer extract unlimited quantities of groundwater. They are now limited to a maximum of 7,000m^3/yr under two conditions - groundwater flow must remain unaltered and its quality must not deteriorate. The right to alter and modify Spain's water balance now belongs to the Government alone operating through the National Water Board.

Spain, a country that traditionally preferred using surface water to groundwater, is now belatedly following international trends, as it plans to increase groundwater usage by 280%.

(Source: The Groundwater Newsletter, Vol 17, No. 2)

Editor.

Delaware, U.S.A.

The per capita water use is estimated at 84 U.S. gallons per day in homes with conventional toilets. When water-conserving appliances are used, per capita water use can be cut to 47 U.S. gallons per day.

(Source: Water Newsletter, Vol 30)

Editor.

CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

The **GSI Groundwater Newsletter** aims to improve communication among the many scientists and engineers involved with groundwater. It includes news, developments, reviews and opinions on all aspects of groundwater - exploration, development, management, water quality, pollution and energy. It is published at three-monthly intervals.

Your contribution to the dialogue would be welcome. In particular for the next issue send in articles on the use of peatland for waste disposal. These should reach the Geological Survey before **1st May 1988.** All items should be as short **(maximum 350 words),** interesting and newsworthy as possible

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