THE GSI GROUNDWATER NEWSLETTER

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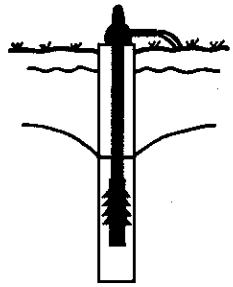

NUACHTÁN SCREAMHUISCE SGÉ

- *Taiscéalaíocht*
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- *Tuairimí*

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GROUNDWATER EXPLORATION AND DEVELOPMENT

Applied Geophysics in Groundwater Exploration

Setting the scene

This is the first in a series of ten articles which will demonstrate the contribution applied geophysics can make to groundwater exploration. The series draws largely on the work of a succession of M.Sc. coursework projects completed by students of the Applied Geophysics Unit at U.C.G. Since the intention is to demonstrate applications of geophysics, the theory behind individual methods will not be given. A reading list will be included.

The decision to include a geophysical survey in a groundwater exploration programme largely depends on economic factors. Time and money can often be saved by eliminating 'barren' ground with a well designed geophysical survey which is included in the early stages of an exploration programme. Once an area of groundwater potential has been outlined detailed surveys can also be carried out to define drilling or abstraction targets. It must be emphasised that geophysical surveys, when used, usually form part of an integrated approach to exploration and should never be used in isolation.

Selection of appropriate geophysical survey methods for an exploration programme depends largely on geological and geophysical factors. Geological factors are chiefly concerned with geological structures which control possible groundwater sources in the survey area. Physical property contrasts such as resistivity, electrical conductivity or density associated with these geological structures, control the choice of suitable geophysical survey methods.

The accompanying list illustrates possible groundwater sources, geophysical exploration methods used and the arrangement of subsequent articles. Article No. 9 will cover geophysical well logging and No. 10 will include a discussion and reading list.

Article No.	Groundwater source	Geology	Location	Geophysical methods	Source
2	Fault spring	Reef lst. Oolitic lst.	Limerick	Resistivity	Sheehan, 1982
3	Contact spring	Reef lst. Calp lst.	Limerick	Resistivity	McDonnell, 1982.
4	Karst lst.	Reef lst. Oolitic lst.	Galway	Resistivity EM-VLF	Morgan, 1983
5	Alluvial valley	Volcanic bedrock	Virgin Islands	Resistivity Seismic Gravity	Tombs and Barton, 1979
6	Gravel ridges	Sst. lst. bedrock	Roscommon	Resistivity EM-VLF Seismic	Keohane, 1984
7	Fault	Old Red Sst.	Kerry	Resistivity EM-VLF	Ní Cholmáin, 1985
8	Fractures	Granite	Galway	Resistivity EM-VLF EM-VLF-R	Mulcahy, 1984 Barton and Derham, 1987

Kevin Barton, Applied Geophysics Unit, U.C.G.

Permanent Well Points - A Means of Water Supply

Rosslare Golf Club has installed a permanent wellpoint system to develop a fresh water lens beneath the links course to provide irrigation water for greens and fairways. The low rainfall and high number of sun hours that characterise this part of the sunny south-east mean that the Rosslare course requires a higher amount of irrigation than is required on inland courses.

The links course is located on a sand bar that projects into Wexford Harbour and is surrounded by salt water at high tide. The prospects of finding fresh water at depth beneath the site were therefore slim even though the site is underlain by the productive Wexford limestone aquifer.

However, a fresh water lens was found floating on salt water within the sand bar and the club developed this with a wellpoint system. Twenty-five six-metre long wellpoints were located along a 30 metre long header pipe which was connected to a 15 H/P sykes vacuum pump. The system provides 545m^3/d (5,000 g.p.h.) of water suitable for irrigation with a chloride concentration of 97mg/l. The groundwater is slightly coloured due to peat layers within the dune sequence.

Kevin Cullen, Consulting Hydrogeologist.

Future Development of South Wexford Limestone Aquifer

The limestones south of Wexford town have been proven to be a major source of groundwater. Wexford County Council intend to augment the south regional supply and have commissioned P.H. McCarthy Son & Partners to design the Fardystown Regional Water Supply Scheme. The anticipated demand is 16,500 m^3/d (3.6 m.g.d).

Fourteen trial well sites were selected in the Bridgetown-Mayglass area south of Wexford Town.

The area is underlain by the high yielding Hardygreggan Dolomite. The drilling programme was carried out in the early part of this year.

The programme was most successful with high yields being encountered in the highly fractured dolomitized limestones of the area investigated. Of the fourteen wells drilled, five had yields in excess of 1650 m^3/d, seven had yields in excess of 1,100m^3/d. Only two of the wells had disappointing yields. This anomaly can be explained by the underlying geology. The two poor yielding wells were drilled in the Redmore Micrite, whose units have lower yields than the Hardygreggan Dolomite.

The programme established that the Bridgetown-Mayglass area can meet the demand of 16,500 m^3/d (3.6 m.g.d.) and production wells will be drilled in due course.

Kieran O'Dwyer, K.T. Cullen & Co, Michael Hand, P.H. McCarthy Son & Partners, and Gerry Forde, Wexford County Council.

Drillex Exhibition at Stoneleigh, England. 8-9th April

This exhibition caters for the mining, quarrying, mineral exploration and well drilling industries.

An item which caught my eye was a Down-the-Hole hammer which can operate at very high pressure in order to increase efficiency and which also has the facility to place casing and drill simultaneously. Another exhibitor was demonstrating a small machine for regrinding of button bits used in DTH hammers. By carrying out this exercise it was claimed that bit life could be increased by 40%.

It was also interesting to note the various drilling fluids that are available for boring in difficult terrain. Among other exhibits were P.V.C. casing and screens, friction welded drill rods and adaptors.

A number of papers were also given. These have been published by the Institution of Mining and Metallurgy. 208pp. Price Stg. £25.00.

Des Meehan, Waterwell Driller.

Groundwater in the Carboniferous Limestones of South Wales

The Carboniferous Limestones in South Wales outcrop mainly on a narrow coastal band, 24-32 kilometres wide between Pembroke and Severn Bridge at Chepstow. This coastal area covers approximately 1000 sq km and supports a population of approximately 0.75 million people. Employment is mainly in traditional heavy engineering and quarrying, diversifying more recently into pharmaceutical, chemical and computer-related industry.

The Carboniferous Limestone is the most important aquifer in South Wales. Groundwater is contained within and moves through enlarged fissures and the greatest yields are obtained from major springs of which 8 are licenced to abstract 2.0Mm^3/yr (64 ls^{-1}) although flows in excess of 1000 ls^{-1} have been recorded in some. In comparison, the estimated total groundwater abstraction for the Republic of Ireland (Wright et al., 1982) is 90 Mm^3/yr.

The need to dispose of domestic and industrial wastes led to the selection of abandoned limestone quarries as potential landfill sites. However previous studies had identified the vulnerability of limestone aquifers to contamination from this practice.

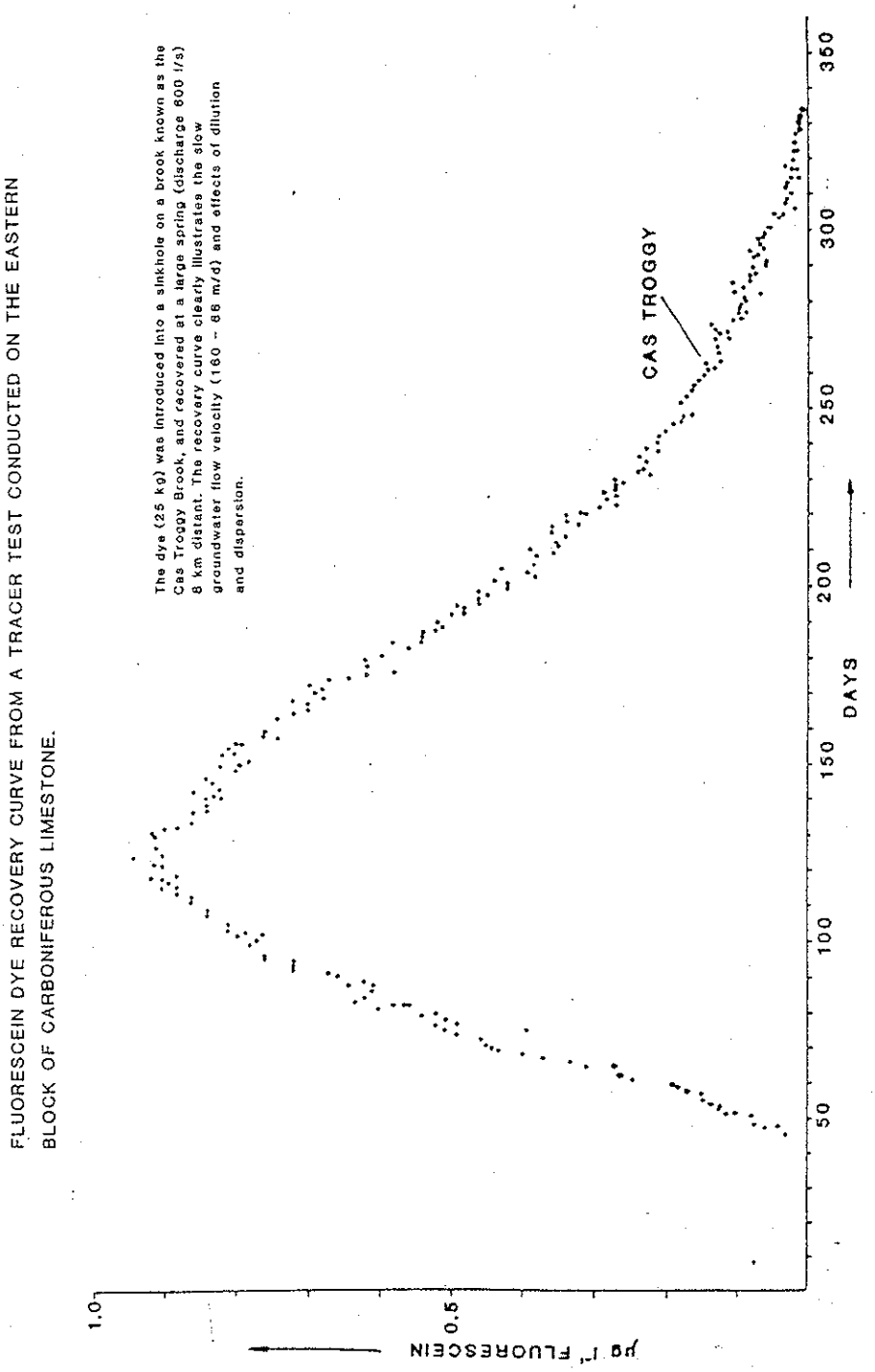
A catchment protection policy is being initiated by Welsh Water with help from the Water Research Centre (WRC) and local Government bodies. This involves catchment area delineation by traditional geological and hydrogeological methods and by the use of quantitative artificial tracer techniques (see example below). These have enabled the identification of potential pollutant pathways affecting specific groundwater abstractions.

Over the past 7-8 years, numerous surveys have been carried out in South Wales for local waste disposal authorities to assess the suitability and possible environmental impact of proposed waste disposal sites. WRC has also made intensive studies at two landfills as part of a national programme of research, funded by the Department of the Environment, into the behaviour of wastes in landfills and their effect on the major aquifers. These studies have yielded data which has improved the knowledge of the regional aquifer characteristics (transmissivities, flow patterns, flow velocities). The flow velocities in the Carboniferous Limestones of South Wales show an increase in solutional development of the fracture patterns present (i.e. karstification).

More recently studies have diversified to examine different and changing land use practices affecting the aquifer. This has involved the identification of further point pollution sources (i.e. industrial spillages) and diffuse pollution sources (agricultural practices).

The Carboniferous Limestone aquifer in South Wales is similar to parts of the Carboniferous Limestone aquifer in Ireland. However, the lower population density in Ireland and less industrial development means that septic tank

effluent and agricultural practices pose the major pollution threat with a lesser threat from waste disposal. However the need to prevent aquifer contamination is common to both countries and similar studies in Ireland would help to improve the knowledge of the characteristics of Ireland's most important aquifer.



Phillip Aldous and Jerome Keohane, Water Research Centre, U.K.

A Solid Waste Landfill in a Karst Area

During the summer months of 1985 springs and wells in the vicinity of an 11 year old, privately operated landfill, sited in a disused limestone quarry and receiving mixed domestic, commercial and industrial waste near Carrickmacross, Co. Monaghan, became contaminated. Water tracing experiments and analyses of water samples were undertaken to determine if the landfill was the cause of the contamination.

Tracing experiments using a variety of tracing agents, including sodium (Na) fluoroscein, established that water sinking at a swallow hole 150 metres northwest of the landfill passed beneath the landfill and emerged at risings to the south and southwest. A dye budget analysis of the Na fluorescein tracing experiment showed that most of the water flows along the principal joint system orientated NNW-SSE and emerges to the south of the landfill. The linear velocities for this and the other tracers used were between 56 and 68m/hr - considerably in excess of normal groundwater flow rates - suggesting that flow is in large fissures or in larger discrete conduits. The dye budget analysis also showed that a smaller proportion of the water flows to the southwest - the area in which the contamination had occurred. Flow in this direction appears to utilise a secondary E-W joint system with linear velocities of between 25 and 35m/hr suggesting that the flow is in smaller fissures. The tracing experiments therefore confirmed the possibility that the landfill was the source of the contamination.

The results from two sets of analyses of water showed clear evidence of contamination. Concentrations of 0.8 and 2.0 mg/l ammonia (NH_4+) were recorded at the rising receiving most of the water flowing beneath the landfill (E.C. M.A.C. for NH_4+ is 0.5 mg/l) and high K/Na ratios, both of which usually indicate vegetable-based contamination from sources such as landfills. However, the water sinking to the north of the landfill also had elevated NH_4+ (0.4 and 0.7 mg/l) concentrations and high K/Na ratios indicating that the water was contaminated before it sank beneath the landfill. This, together with an inspection of well-site conditions in the vicinity of boreholes evidencing contamination, indicated that the contaminants were probably derived from run-off from dungsteads in farmyards and not necessarily the landfill.

The investigators concluded that at the time of the investigation there was little evidence that the landfill was the cause of the contamination.

Brendan Mullen, Monaghan County Council and Richard Thorn, Sligo R.T.C.

Waste Disposal Sites and Groundwater Quality

Opinions on the effects of waste disposal sites on groundwater are varied, as was evident at the IAH seminar held in Portlaoise, 1986. Part of the problem is a lack of data on the subject in Ireland, although much work, both laboratory and field-based, has been carried out in other countries, perhaps most notably in the U.S.

As part of an M.Sc., I decided to carry out research in this area, investigating groundwater quality in the vicinity of several waste disposal sites in Leinster. This work was carried out in conjunction with the Geological Survey of Ireland and the State Laboratory, and with the co-operation of several County Councils. Samples were taken from a number of boreholes at each site on a monthly basis over a period of six months, and a full chemical analysis carried out on each sample.

The main drawback encountered was the need to use pre-existing boreholes (generally domestic supplies) which were not always spatially distributed in the most desirable configuration. However, in all, six sites were selected where a sufficient number of sampling points existed; these sites also span a range of hydrogeological conditions. Three are located in disused sand/gravel pits, two in disused limestone quarries, and one is a containment site. Due to a lack of suitable observation boreholes in the vicinity, no bog sites were included.

The results show that two of the sites, one in a sand/gravel pit, the other in a limestone quarry, are causing pollution of nearby wells. In contrast, two of the other sites in what are, at least superficially, similar settings to the former two, show little or no evidence of causing groundwater contamination. The third sand/gravel pit site shows some evidence of pollution, but this is inconclusive. The containment site does not appear to be causing problems, although as it has been operating for less than three years now, the long term effects are as yet unknown. An interesting point is that one of the sites causing pollution ceased operations in 1976; leachate production is obviously still going on, eleven years later.

One important fact confirmed by these results is that hydrogeological conditions vary from site to site, and each must be viewed as a separate entity. Although some people may cite the "good" or inconclusive results to suggest that unplanned waste disposal sites do not cause environmental problems, the other results indicate that the problems do exist. How widespread they are is difficult to say.

Can we afford to take chances with our groundwater resources? Are we justified in doing so?

The full report on this project will be available in early 1988.

Suzanne O'Sullivan, Environmental Sciences Unit, TCD.

Large-scale Potable Water Disinfection by U.V. Treatment.

U.V. treatment of small water supplies was considered in two previous issues of the Newsletter - No's. 2 and 3. According to information supplied to me by Peter Costello, Peter Costello & Co. Ltd., recent developments mean that there is now no practical limit to the volume of water that can be treated by the U.V.method. A U.V. plant capable of treating up to 12 million gallons per day has been installed by Thames Water Authority to treat raw water from Chalk boreholes, avoiding the need for superchlorination and dechlorination. The plant is fully automatic, with continuous monitoring of U.V. intensity and a built in back up system in the event of problems such as bulb failure.

Donal Daly, Geological Survey of Ireland

Septic tanks: Areas at Water Pollution Risk

The adjoining map shows the general areas susceptible to pollution of either surface water or groundwater from septic tanks. Septic tanks can cause pollution either where:

(a) Soakage is inadequate;

(b) Soakage is excessive.

Soakage is inadequate in areas where the soils consist of gleys and peat, and results in pollution in backgardens and streams.

Where soakage is excessive, groundwater is at risk. The high risk areas occur where karstic limestone is at the surface or is overlain by a thin permeable overburden. The medium risk areas are the gravel aquifers and the bedrock aquifers where they are overlain by a relatively thin permeable overburden.

As the map is only a general guide at a small scale, there are many areas (generally small) which will not conform to the classification on the map. In particular, areas with wells in poor aquifers, which will be at risk where bedrock is at or close to the ground surface, are not shown.

References:

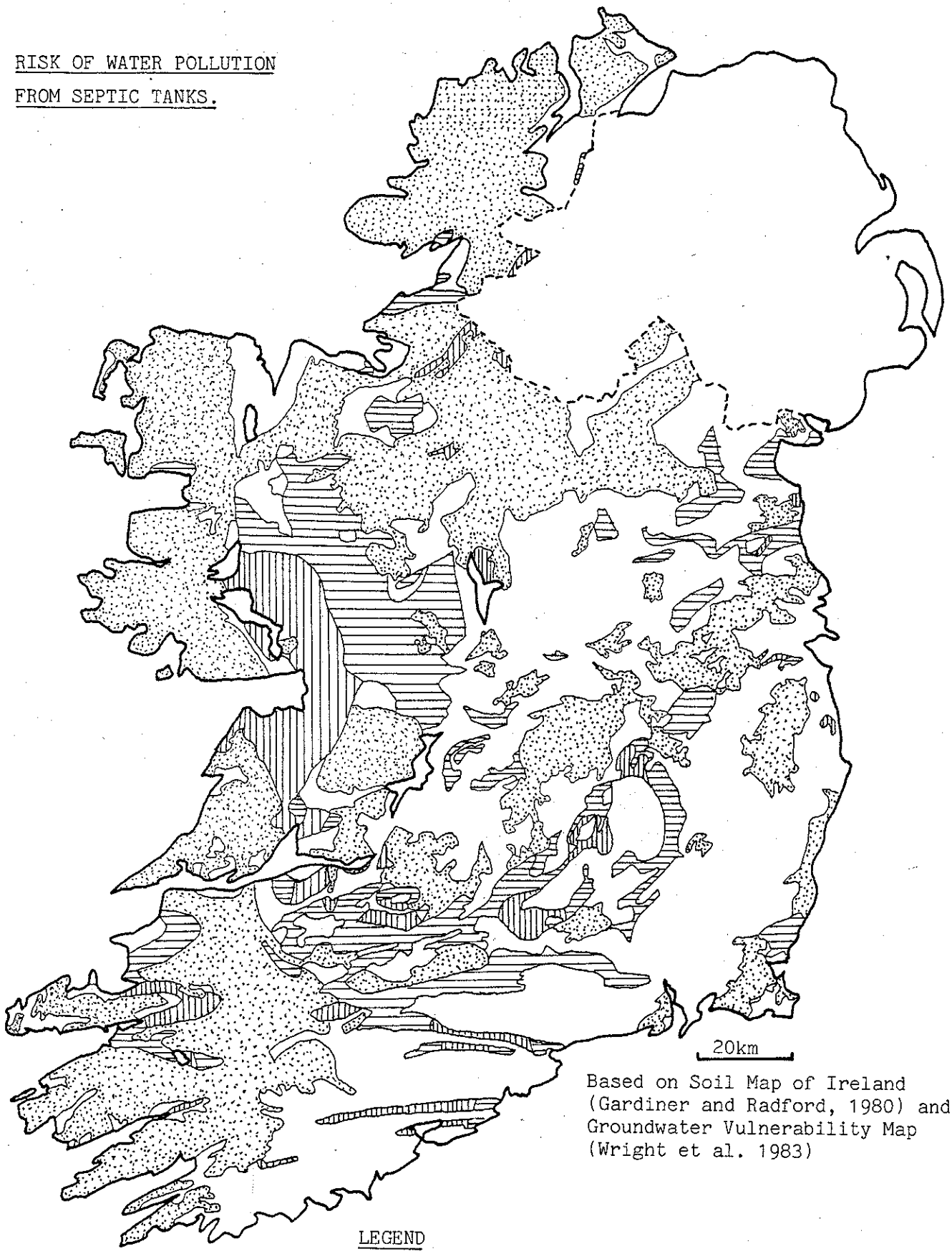
Gardiner, M.J. and Radford, T. 1980. General Soil Map. An Foras Talúntais.

Wright et al., 1983. Groundwater Vulnerability Map. Geological Survey of Ireland.

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

Donal Daly, Geological Survey of Ireland.

RISK OF WATER POLLUTION
FROM SEPTIC TANKS.



Based on Soil Map of Ireland (Gardiner and Radford, 1980) and Groundwater Vulnerability Map (Wright et al. 1983)

LEGEND

Medium - High risk to surface water

High risk to groundwater

Medium risk to groundwater

Nitrate Problems in Domestic Water Supplies

A survey of wells in the stretch of the Barrow Valley between Athy and Carlow, carried out by Trinity College Environmental Sciences M.Sc. students in April 1987, has shown up a potential problem with nitrate levels. A total of 21 wells (20 private wells and one group scheme) were sampled and subjected to a full chemical analysis, and the average nitrate concentration was found to be 10.7 mg/l NO_3-N (47 mg/l NO_3), with values spanning a range from 1.2 mg/l NO_3 to 22.8 mg/l NO_3-N. Nine of the wells exceeded the EEC guide level of 5.6 mg/l NO_3-N (25 mg/l NO_3). While a single-occasion sampling is not necessarily representative of long-term average concentration, these values are clearly high enough to merit further investigation.

Problems of high nitrate in groundwater in other European countries are often attributable to leaching from nitrogen fertilizers. However, Daly and Daly (1982)* have suggested that local point sources of contamination are responsible in the Barrow Valley, and the results from these wells provide some evidence for this. Although ammonia concentrations were generally low (all <0.1 mg/l), three wells had very high potassium concentrations (>25 mg/l) and elevated chloride and sulphate levels, and a total of eight wells had high K/Na ratios (>0.3), suggesting that the contamination is from a local organic source in at least some cases. All the dwellings are served by septic tanks, nearly all of which are reported to drain to soakpits rather than pipe distribution systems, and ten of the wells are on farms with potential point sources of contamination (silage pits, animal housing units).

If the source of nitrate is a diffuse one, there is no easy solution to the problem. However, if localised contamination in the immediate vicinity of the supply well, rather than general contamination of the aquifer, is involved, it may be that the nitrate concentration of 4.3 mg/l NO_3-N from the high- yielding group scheme borehole is more representative of general aquifer conditions. Nevertheless, the high nitrate concentrations in these domestic water supplies, and the possibility of bacteriological contamination if a faecal source is responsible, should not be ignored. Presumably the answer lies in making the general public more aware of the potential risk posed by domestic and agricultural wastes to their own water supplies, by means of publications such as GSI Information Circular 85/1 (Groundwater Quality and Pollution by D. Daly) and Environmental Awareness Bureau Resource Source Guide No. 3 (Groundwater, by R. Thorn).

* Daly, D. and Daly, E.P. 1984. A review of nitrate in groundwater and the situation in Ireland. Irish Journal of Environmental Science, 3, 1-13.

Catherine Coxon, Environmental Sciences, T.C.D.

POPE JOHN PAUL II Commends Hydrogeologists at IAH Congress

The XX Congress of the International Association of Hydrogeologists (IAH) was held at the HQ of the Consiglio Nazionale Richerche (Piazza Aldo Moro), Rome, from 13th to 17th April, 1987. The theme of the Congress was "Groundwater for Development". I was the only member from Ireland present.

There were about 160 participants, many from Italy, but a fair number from all over the world, including USSR, Japan, China, Australia, Botswana, Nigeria, Egypt, USA, South Africa and Brazil. There were some 105 papers presented.

Many of the papers dealt with groundwater investigations, development, uses and management as major items in the development of backward areas, in particular in arid and semi-arid regions. There were a few papers on groundwater usage against drought and famine. There were also a few papers on groundwater development as a component of the overall development of industrialized and advanced regions, with the usual warnings on pollution. There was a little on energy extraction from groundwater.

On Wednesday 15 April, some 90 IAH members attended a General Papal Audience in the Vatican. The IAH President, Professor M.R. Llamas, had arranged the audience, and the IAH members were seated in front. In his speech, **His Holiness, Pope John Paul II** made a special reference to the hydrogeologists present. He said **"I am especially pleased to welcome the members of the IAH gathered in Rome for their Twentieth Congress. Dear friends, the fact that nearly seventy countries are represented in your membership indicates the importance of your field of research and also serves as a fine example of scientific co-operation for the good of the human family. I wish to commend you for your interest in assisting developing nations. By doing so you are working for the peace and justice that we all seek for our world. May God bless you in your deserving efforts".**

On Thursday, 16 April, there was a day-long field trip organised by the ACEA (Azienda Communale Electricita ed Acque - Rome). The two major karst springs developed to supply potable water to Rome were visited; they are located in the hills near Rieti, some 80 to 100 kilometres from Rome. The smaller spring at Capore was first visited; 5.00 m^3/sec (permanent) are diverted from this limestone spring into the Rome supply. The larger group of springs at Peschiers (near Cittaducale) were then visited; 16.00 m^3/sec (permanent) are diverted from this group of springs into the Rome supply.

The XXI Congress of the IAH will beld at Guilin City, People's Republic of China, from 10 to 15 October, 1988.

David Burdon, Minerex Limited.

N.B.S.T. Grant for Groundwater Monitoring

The recent round of N.B.S.T. Scientific Research Awards included a grant to Catherine Coxon of the Environmental Sciences Unit, T.C.D. and Richard Thorn of the School of Science, Sligo R.T.C., to enable them to carry out groundwater chemistry and quality investigations in Counties Carlow, Kildare, Sligo and Roscommon.

Groundwater accounts for 25% of the freshwater used in Ireland but, unlike surface water, is not part of a national programme of water quality monitoring, and sampling is usually carried out on an ad hoc basis. As a consequence, the extent to which short term fluctuations in groundwater chemistry and quality occur remains largely unknown. The study, through the use of intensive sampling procedures, has as its main aim the elucidation of the nature of such fluctuations in aquifers ranging from rapid flow-through, low-storage karstified limestone aquifers to intergranular, high-storage sand and gravel aquifers. It is hoped that the results of this part of the study will provide a rational basis for the interpretation of isolated or sporadic water analyses and for designing groundwater quality monitoring programmes.

A second objective will be an attempt to determine whether particular contaminant sources, which have been located through land-use mapping techniques, water tracing etc., can be identified by using physical, chemical and microbiological indicator parameters.

The grant allows for the employment of two research assistants during the course of the investigation in addition to providing funding for the collection and analysis of water samples and for carrying out field investigations.

Richard Thorn, Sligo R.T.C.

Another Honour for David Burdon

Dr. David Burdon, one of Ireland's most esteemed scientists and geologists, was made an Honorary Member of, and presented with a gold medal by, the European and Mediterranean Water Planning Commission. This Commission, which is affiliated to the U.N., was established with David Burdon's assistance earlier in his career.

Donal Daly, Geological Survey of Ireland.

IQUA Seminar "Quaternary Deposits and the Environment"

The Irish Association for Quaternary Studies (IQUA) is organising a seminar entitled "Quaternary Deposits and the Environment" to mark the European Year of the Environment. The aims of the seminar are to show firstly, how Quaternary deposits influence the effects of human activities on the environment and secondly, how Quaternary deposits as a major part of the environment, influence human activities.

The provisional programme includes the following papers:

Soils, land-use and environmental protection by Dr. J. Collins, UCD;

Coastal erosion of Quaternary deposits by Dr. B. Carter, University of Ulster;

Reinstating disused gravel quarries by Mr. F. Norman, Roadstone Provinces Ltd;

Quaternary deposits as foundation materials by Professor E.T. Hanrahan, UCD;

Land drainage and Quaternary deposits by Mr. T. Gleeson, AFT;

Quaternary deposits and water pollution by Mr. D. Daly, GSI;

Environmental geology mapping by Dr. R. Creighton, GSI;

A guide to the interpretation of Quaternary deposits for non-Quaternary specialists by Dr. W. Warren, G.S.I.

The seminar will be held on 20th November 1987 at the Geological Survey of Ireland, commencing at 9.30 am. There will be a small entry charge to cover the cost of publishing the papers. Non-members are welcome. For further information contact Ronnie Creighton or myself at the Geological Survey (tel. (01) 609511).

Donal Daly, Geological Survey of Ireland.

Silage Effluent and Water Pollution

With pollution of streams abounding this summer and with alleged risks to health being caused by high aluminium levels in some treated surface waters, it could be argued that groundwater is far superior as a source of water supply! However we have received information on the pollution of several public, group scheme and private groundwater supplies, mainly by silage effluent. These have received little publicity, one reason being that fish weren't killed! Pollution of groundwater supplies by silage effluent will be dealt with in the next issue of **The Newsletter.**

Donal Daly, Geological Survey of Ireland.

Con Flynn Retires from the State Laboratory

On the 13th of August, a large group of colleagues and friends gathered in the canteen of the State Laboratory at Abbotstown to wish Con Flynn well in his retirement from his post as Senior Chemist. A presentation was made by the State Chemist, Mr. P.C. Walshe, as a token of the respect and affection in which Con is held by all his colleagues.

Con has spent almost forty years in the public service, including thirty-three at the State Laboratory. Amongst his other duties, he has been responsible for chemical analyses of many hundreds of water samples submitted by the Geological Survey, the Land Commission, and other State agencies.

In more than twenty years of collaboration, we in the Geological Survey have come to know Con as a friend, colleague and adviser. His knowledge and expertise built up over a lifetime on the quality of Ireland's groundwater has been of the greatest value in helping to establish the initial data base of groundwater quality for Ireland.

For the hydrogeologist as for the engineer and consumer the need to be able to rely on the accuracy of water analyses is of primary importance. But that is only the beginning. The interpretation of results and their relation to their geoenvironment is also essential if best use is to be made of the results. Con's enthusiastic interest and readiness to discuss and guide us in this complex field is most gratefully acknowledged.

We look forward to continued collaboration with his colleagues in the State Laboratory and wish him a long and happy retirement.

Bob Aldwell and Geoff Wright, Geological Survey of Ireland

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 will include news, developments, reviews and opinions on all aspects of groundwater exploration, development, management, water quality, pollution and energy. It will be published at three-monthly intervals.

Your contribution to the dialogue, particularly on pollution from silage effluent, would be welcome. For the next issue it should reach the Geological Survey before **1st November, 1987.** All items should be as short (maximum 300 words), interesting and newsworthy as possible.
