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THE GSI GROUNDWATER NEWSLETTER

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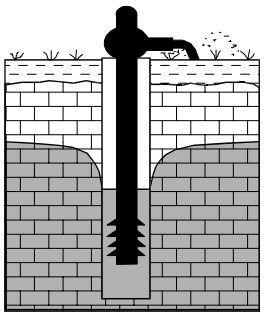

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In This Issue

Phosphorus is a significant contaminant and cause of **eutrophication in surface water** in Ireland. It is not generally a problem to groundwater and is not likely to be in the future. The reasons for this are: firstly, orthophosphate precipitates readily in soil and subsoil; and secondly, the maximum admissible concentration for drinking water (5000 µg/l P_2O_5 = 2200 µg/l P) is rarely approached, except in areas of gross contamination. However, in surface waters the concern is at much lower levels; total phosphorus in excess of only 20 µg/l may trigger eutrophication. Recent work by Gareth Kilroy and colleagues at the Environmental Sciences Unit, TCD (see page 2), is showing that in certain hydrogeological situations, concentrations greater than this may be present in groundwater. These situations are where groundwater is extremely or highly vulnerable to contamination; in particular where fissured bedrock is at or close to the ground surface and where the soils and subsoils are sandy. So, **while phosphorus does not present a problem to groundwater, groundwater may act as a pathway for P to targets such as lakes, streams and wetlands.** This highlights the need to take groundwater into account in catchment monitoring and management schemes.

A significant potential hazard for both surface water and groundwater is **landspreading**. Mark Conroy and Stan Cullen (page 5) discuss the **site investigations** required as part of **IPC licensing**, and give some excellent advice on the use of **tractor mounted auger systems** as a quick, effective means of getting soil and subsoil samples, and checking depth to rock with minimal damage to fields.

On page 7, Colette Cronin gives advice on **corrosion**; Jenny Deakin outlines **how limestones are being categorised by the GSI** on page 9; Bruce Misstear discusses **a quick method for pumping test analysis** on page 10; and on page 16, Matthew Parkes describes the start of an exciting new programme of choosing Ireland's **geological heritage areas**, with **karst** as the first theme.

Editor

Phosphorus in Irish Aquifers: A Brief Assessment at National and County Scale.

Introduction

Phosphorus (P) is a frequently neglected parameter in studies of groundwater chemistry and quality, because the maximum admissible concentration for drinking waters (5000 μg l^{-1} P_2O_5, = 2200 μg l^{-1} P) is rarely approached, except in areas of gross localised contamination. In surface waters, however, the concern with phosphorus is at much lower levels: total phosphorus concentrations in excess of only 20 μg l^{-1} P may trigger eutrophication (Champ, 1998). This paper is concerned with the desk study component of a research project into P in Irish aquifers.

Phosphorus data from samples recovered in 1995 as part of the Environmental Protection Agency's National Groundwater Quality Monitoring Program (NGQMP) were investigated to identify any spatial distribution patterns or trends. County Limerick was investigated in greater detail to examine whether specific hydrogeological parameters exert significant controls on P levels.

Conventional wisdom is that most phosphorus is retained in the soil zone by adsorption and by precipitation as hydroxyapatite. However, in some situations (e.g. non-calcareous aquifers or high permeability fissured and karstified aquifers), this may not provide complete attenuation. Previous studies have identified phosphorus leaching in areas with sandy soils, shallow water tables, and in phosphorus saturated soils (Breeuwsma *et al*., 1995).

Assessment at National Scale

The data analysed comprise single results for molybdate reactive phosphorus (MRP) from 177 groundwater sampling locations across the Republic of Ireland. The samples were recovered between October and December 1995. A frequency distribution histogram of the data is presented in Figure 1. The data are skewed to the right; 69% being reported at 20 μg l^{-1} or less. Approximately one third (31%) of the data are greater than 20 μg l^{-1}, the level above which eutrophication may occur. This represents a potentially important input to rivers and lakes.

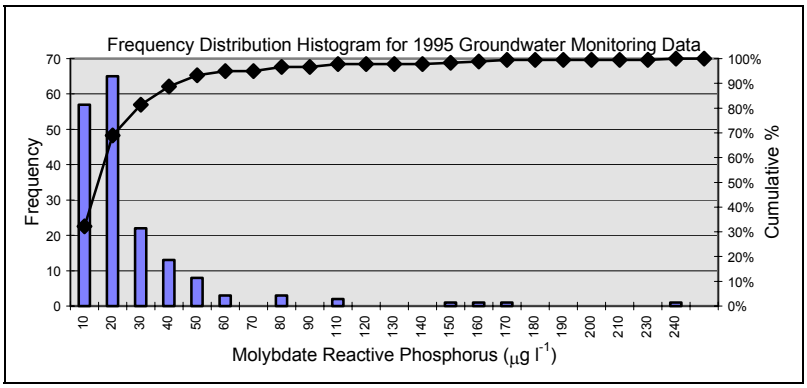

Figure 1 MRP Levels in Irish Groundwaters (EPA data for 1995)

The data exhibited large spatial variation across the country, but the small number of samples in many of the counties make inter-county comparison difficult. Further analysis, including the 1996 and 1997 data from the NGQMP (which will be available shortly), will be undertaken with GIS. Specifically, hydrogeological information layers and surface water quality data will be interrogated and interpolated to improve the visualisation of spatial trends at a national level.

Assessment at County Scale: Limerick

County Limerick was chosen for more detailed study due to the relatively large number of samples recovered (18) and since a detailed

groundwater protection scheme has been carried out by the Geological Survey of Ireland for this county (Deakin, 1994) (Deakin, Daly and Coxon, 1998). The Limerick Groundwater Protection Scheme includes a set of seven maps: bedrock geology; subsoils (Quaternary geology); depth to bedrock; hydrogeological data; aquifer type; groundwater vulnerability; and groundwater resource protection. All 18 locations were identified on each map and their characteristics noted. Additional characteristics including site type (well or spring), and in the case of wells, well depth and standing water level, were included where available. Soils information was obtained from the National Soil Survey of Ireland survey of Limerick soils (Finch & Ryan, 1966). Table 1 below lists the mean MRP concentrations reported for each parameter.

Table 1 Mean groundwater MRP levels in Co. Limerick for selected parameters

PARAMETER	Sub-parameter	[MRP] μg l^{-1}		Number of
		Mean(1)	STDEV	Samples
Aquifer type	Regionally Important - Fissure Flow	34.2	39.5	5
	Locally Important - generally moderately productive	32.0	n/a	2
	Locally Important - Moderately productive only in local zones	28.7	22.6	9
	Poor - Generally unproductive except for local zones	19.0	n/a	2
Bedrock	Lower Carboniferous Limestones	35.3	30.5	11
	Namurian Sandstones and Shales	28.0	n/a	1
	Silurian Sandstones	23.5	n/a	2
	Devonian, Old Red Sandstone	17.0	12.0	4
Soil Type	Grey-Brown Podzolics	54.6	35	5
	Brown Earths	41	n/a	2
	Gleys	16	8.4	11
Subsoils	Silurian Slope Deposits	37.0	n/a	1
	Sandstone Till	9.7	1.5	3
	Limestone Till	41.4	34.1	8
	Alluvium and Limestone Till	24.0	n/a	2
	Till with Gravel	21.5	10.3	4
Site Type	Well	31.9	26.3	16
	Spring	10.5	n/a	2
Well Depth (m)	<50	57.3	44.2	4
	50-79	30.5	19.9	4
	80-102	24.0	4.6	3
Depth to Bedrock (m)	<10	36.8	30.3	11
	10-20	19.5	12.1	4
	>20	16.0	3.6	3
Standing Water Level (m)	<10	37.6	25.9	5
	10-20	23.8	14.3	5
	>20	17.0	n/a	1
Vulnerability	Probably Extreme	53.5	34.4	4
	Probably High	27.7	20.5	10
	Probably Moderate	9.5	n/a	2
	Probably Low	10.5	n/a	2

Note (1): Shaded values are greater than the adopted threshold of 20 μg l^{-1}.

This limited preliminary investigation highlighted several trends. Samples recovered from locations with Old Red Sandstone bedrock were generally low in MRP. Large variability was reported for all sampled subsoil types except for the sandstone till, for which all values were below 20 μg l^{-1}. The more impervious gleys were generally associated with lower groundwater MRP levels than the more free draining brown earths and grey-brown podzolics. Increasing well depth, overburden thickness and unsaturated zone thickness resulted in a decrease in MRP. Both springs sampled had low MRP levels. Samples recovered from high and extreme vulnerability zones were generally above 20 μg l^{-1}. A detailed field program will be undertaken to investigate further hydrogeological controls at local levels.

Acknowledgements

This research is being funded by a Forbairt Basic Research Grant. The authors would like

to express their gratitude to the Environmental Protection Agency for providing the 1995 groundwater P data. The original format of this paper (Kilroy *et.al.*, 1998) is published in the proceedings of the OECD sponsored workshop on agricultural phosphorus losses to water, held last June at the Greenmount College of Agriculture and Horticulture, Antrim. Permission from the editors (Foy and Dils, 1998) to reproduce this paper here is gratefully acknowledged.

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Kilroy, G., Coxon, C., Rybaczuk, K. and Allott, N. (1998) Phosphorus in Irish Aquifers: implications for input to surface waters. In: Foy, R.H. and Dils, R. (eds.) *Practical and innovative measures for the control of agricultural phosphorus losses to water*. Proceedings of the Phosphorus Workshop 1998. OECD, Antrim. pp. 160-161.

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Recent Publication

Risk Assessment for Contaminated Sites in Europe - Volume 1 - Scientific Basis (1998)
Price: £25.00 stg. (incl. p+p)
Available from: Land Quality Press, Land Quality Management Ltd., PO Box 5095, Nottingham NG2 6FB, UK (fax: +44 115 9034512)

This book is an output of a Concerted Action on Risk Assessment for Contaminated Sites in the European Union (CARACAS) which was funded by the EU and in which representatives of the DoELG and EPA were participants. It includes a practical state-of-the-art on risk assessment in Europe.

A Rapid Method of Shallow Profiling for Landspreading Assessments (and Other Site Investigations)

Introduction

The purpose of the Integrated Pollution Control (IPC) Licence is to make provision for the protection of the environment and the protection of human, animal and plant life from harm or nuisance. IPC encourages the use of cleaner technologies, the elimination or minimisation of waste and improved efficiency and effectiveness of pollution control.

The landspreading of agricultural slurries and some industrial sludges results in the recycling back to the soil of nutrients in an environmentally friendly manner. Landspreading of organic waste is regulated under the Environmental Protection Agency (EPA) Act (1992), the Waste Management Act (1996) and the Water Pollution Act (1990). The EPA requires IPC licences for intensive agricultural plants and industries above certain threshold levels. The need to protect the environment seeks to limit landspreading to areas that are geologically suitable.

It has been estimated that the Pig and Poultry Intensive Agricultural Enterprises generate an estimated 3.4 million tonnes of slurry annually (Carton and Magette, 1998). Approximately 210,000 hectares of land will be required for the disposal of slurries via landspreading under IPC (Daly et al, 1998).

When other IPC regulated industries are included, an extra 30,000 hectares of spreadable land are required, based on details of lands currently submitted to the EPA as part of the IPC application process, by the slaughtering, rendering and dairy processing industries (Daly et al, 1998).

The draft DoELG/EPA/GSI Groundwater Protection Responses for Landspreading (which are summarised in Daly et al. 1998) include a requirement to demonstrate sufficient soil/subsoil cover over the underlying aquifer to limit the risk of contamination.

The Responses suggest that spreading waste on lands is acceptable where it can be demonstrated that a consistent soil/subsoil thickness of at least 2m exists over Regionally Important Aquifers and at least 1m exists over Locally Important or Poor Aquifers.

Geotechnical and Environmental Services have been involved in many landspread assessments for the disposal of wastes from agricultural and industrial enterprises. A number of different techniques have been utilised, with varying degrees of success, to demonstrate that the underlying conditions are satisfactory.

Methods of Investigation

To adhere to the guidelines proffered by the groundwater protection responses, depth to bedrock information is a salient parameter used to assess the suitability of lands for spreading. Field investigations have become an essential part of landspread assessments and are used to confirm existing information, or to provide extra information where it is lacking.

The IPC regulations indicate that 1 site investigation point should be undertaken per hectare in areas of Extreme Vulnerability. In areas of High, Moderate or Low Vulnerability 1 site investigation point should be undertaken per 5 hectares.

At such a density, a surveying technique is required that has the required penetrative depth potential and the speed and robustness for cross-terrain surveying, and is not prohibitively expensive.

Methods employed to demonstrate depth to bedrock in Ireland include: machine-dug trial pits, hand held motorised drilling systems and tractor-mounted augers. Some of the existing systems are described below.

<u>Machine Dug Trial Pits</u>

Trial pits are an ideal method of investigation because one can physically inspect the strata in profile. However, farmers are reluctant to allow the excavation of trial pits on their land. The placing of spoil to one side, during the excavation, disturbs areas of ground and the reinstatement usually results in a mound over the pit area, which can ultimately settle, leaving hollows in places. Boulders and cobbles, which are brought to the surface can often remain on the surface after backfilling.

Hand-Held Systems

Hand held systems that are screwed into the ground by hand, or systems that incorporate a light 2-stroke engine, such as COBRA and rotary hand-held augers, can be difficult to use when probing stiff clays or gravelly material. The motorised systems, such as rotary hand-held augers, can also be dangerous if an obstruction is encountered.

Portable motorised systems, such as the "Minute Man" are more robust and safer to operate, but are more difficult to transport from site to site.

The ideal system needs to be mobile, robust and capable of probing to at least 2m and safe to operate efficiently. Due to the large areas that need to be surveyed it also needs to be quick to operate and cause minimal disruption to the land.

Tractor Mounted Auger Systems

Two companies in the Kilkenny area have independently developed tractor mounted probing systems, which GES Ltd. have successfully utilised. Augering not only demonstrates the thickness of soil/subsoil cover in an area, but also provides a soil profile, which can be described in the report. There is minimal impact to the land and problems of access to certain fields are reduced.

Landfeeds Environmental Ltd, Abbey Business Centre, Kilkenny, developed a tractor mounted augering system based on equipment used for post driving. The equipment is frame mounted and can be fitted to the rear of a tractor in 25 minutes, the auger is retractable for travel on roads and the tractor can comfortably travel at 30 miles/hr between sites. The resulting equipment has been used with considerable success. The system allows for the alignment and operation of the auger to be controlled using a series of hydraulic levers. Auger depths of up to 2.5m can easily be achieved. The additional weight of the posthole driving-head improves the penetration.

Fogarty Drilling Ltd., Gowran, Co. Kilkenny have also developed a tractor mounted auger drill, based around an adapted rotary drilling system. Again the equipment is frame mounted and can be fitted to the rear of a tractor. The auger is capable of drilling 300mm diameter holes to depths of up to 2.8m, which also allows for soil profiling during drilling.

Perhaps the greatest benefit afforded by the augering system is the time saved in the field. Up to 30-40 auger excavations have been undertaken in one day using the two above tractor mounted auger equipment. To date each site has been sampled and classified to BS 5930 standard and backfilled/compacted to ensure minimal property/stock damage. The safety provided by the system and the highly detailed data acquired through its use, ensures that this equipment is the best alternative for a cost-effective approach to detailed landspread assessments.

Conclusions

- When large tracts of land need to be surveyed quickly and at a reasonable cost, a system is required that can probe shallow depths (2m to 3m) and move between sites quickly.
- The tractor mounted systems developed by Fogarty Drilling Ltd. and Landfeeds Environmental Ltd. represent a cost effective solution to meet these criteria.
- The tractor mounted systems can be used for other applications, such as shallow landfill gas monitoring, subsoil profiling for source protection and aquifer protection schemes, and have wide applications for shallow subsoil profiling for all types of site investigations.

References

Carton, O.T. and Magette, W.L. 1998. *Teagasc Manure Management Guidelines with Special Reference to Intensive Agricultural Enterprises*. Teagasc.

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Mark Conroy and Stan Cullen, Geotechnical and Environmental Services

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Corrosion

Background

In the past the GSI have dealt with a number of requests for advice on the issue of corrosion of pipework and well screens in water supply wells. Corrosion results from the interaction of a metal with the environment and can take place anywhere along the water supply system. It is a complicated issue as many factors influence the process. This article summarises some of the causes and effects of corrosion.

Indicators of Corrosion

There are several indications that a corrosion problem is occurring in a system. Some of the more common are:

- Development of pits on the surface of the pumps, pipes and rising mains.
- Perforation of the liners and/or screens of wells.
- Leaking domestic radiator systems and hot water cylinders.
- High dissolved iron or metal content in the water.

Some Causes of Corrosion

- A groundwater is often corrosive when the water is warm, contains either a high or very low level of dissolved salts, has high CO_2 levels, low pH, low hardness, low alkalinity or has elevated concentrations of chloride and sulphate. There have been recent reports of immersion heaters exploding when low pH, hot water ate through the heater element case and flooded the bare wires carrying electricity.
- Iron bacteria can produce gel-like accretions of iron which build up to form a layer of biofilm on the well screen. This biofilm clogs openings in the well screen, and reduces well efficiency over short periods of time. It can also corrode the metal itself due to the production of enzymes under anoxic conditions. A combination of corrosion and precipitation can lead to high iron concentrations in the groundwater.
- Where groundwater is oversaturated with $CaCO_3$ a scale is likely to be deposited on pipes which may protect the underlying metal from corrosion. However it can also severely restrict water flow through the pipework. If the groundwater is undersaturated, the $CaCO_3$ is generally not deposited as scale leaving the metal exposed and therefore more vulnerable to corrosion.
- The correct choice of a suitable metal is very important. In the past poor quality pipes imported into Ireland have been easily degraded in even mildly corrosive environments.
- Corrosion will often occur when two dissimilar metals are joined. The corrosion results from the formation of an electrical current known as a galvanic cell.
- Corrosion can often occur along the joints of galvanised rising main where the galvanising is thinnest and most vulnerable.
- In certain metals, de-alloying can readily occur; one common example is the dezincification of brass. This is where the zinc is removed from the metal pipe thus undermining the structural integrity of the pipe or fitting in question.
- University research is currently examining whether the earth wire in electrical appliances could conduct stray currents to pipes resulting in corrosion.

Courses of Action

- It is advisable to check if neighbours are experiencing corrosion of pipes. Isolated occurrences of corrosion may indicate problems with the quality of the pipework rather than the inherent corrosivity of the water.
- Tony Betts - a corrosion specialist with the Materials Technology Section of Enterprise Ireland (formerly Forbairt) - can be contacted to examine the corroded metal and assess possible causes of corrosion.

- Get the water analysed: water quality parameters such as temperature, pH, CO_2, Eh, alkalinity and conductivity should be measured at the wellhead as these parameters are unstable and may have altered by the time the sample gets to the lab. This will avoid giving a false impression of the hydrochemistry.
- It is essential that the dissolved iron concentration is accurately measured. The groundwater sample should be taken at or close to the wellhead. The sample should be passed through a 0.45µm filter by the lab; this removes any suspended iron, thus ensuring that only dissolved iron is measured and reported.
- It is possible to test the saturation state of a groundwater sample by using the Langelier Index (*LI*). This can be determined once the Total Dissolved Solids, Ca, HCO_3, Conductivity and pH are known. Where $LI > 0$, the water is oversaturated with respect to $CaCO_3$; if $LI < 0$, the water is undersaturated and probably corrosive. Another method used to determine corrosivity is the Ryznar Index (*RI*); this reflects more accurately the encrusting or corrosive tendencies of water.
- Filters containing limestone chippings can be used to remove CO_2 and increase pH. This helps reduce the corrosivity of the water and prolong the life of the pipes.
- If corrosion of casing and screen is taking place then a new borehole will be required either immediately or in a few years.
- In the meantime pumping conditions in the well should be kept constant and
- appropriate in order to minimise drawdown in the well. This will reduce the introduction of oxygen into the system thus controlling bacterial growth in the well.
- When drilling a new well, problems at the existing well should be taken into consideration.
- Casing, screen and pipework should be constructed of corrosion-resistant material such as stainless steel, plastic or fiberglass.
- It is usually worthwhile employing an experienced hydrogeologist to provide advice on well location and design in relation to water chemistry and bacteriology, and to supervise well construction.

Any comments/additional information regarding corrosion in groundwater are welcome.

Relevant Papers

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Colette Cronin, Geological Survey of Ireland.

Categorising Irish Limestones for Groundwater Development and Protection Purposes

Carboniferous limestones are the most extensive rock type and most important aquifers in Ireland. They are variable in their hydrogeological characteristics: they have permeability systems in a continuum between fine fractures and large conduits; permeability usually decreases with depth; the degree of solution/karstification is highly variable, yet solution has impacted on all the limestones to some degree (and therefore all can be said to be karstified); conduit flow is a major component of groundwater flow in some circumstances but not in others where virtually all flow is in fractures. The hydraulic properties vary depending on the limestone lithology, degree of bedding, structural history and position within regional groundwater flow systems.

Increasing development of groundwater and, more importantly, the requirement to protect groundwater has led to the need to improve our conceptual understanding of Irish limestones, and to put each limestone unit into an aquifer category (in effect compartmentalising the broad range of hydrogeological regimes).

All limestones are assigned to one of three basic categories depending mainly on their permeability, areal extent, and storage capacity – Regionally Important Aquifers **(R)**; Locally Important Aquifers **(L)**; and Poor Aquifers **(P)**. In categorising a limestone unit into one of the three broad aquifer categories, the following factors are examined:

- Lithological and structural characteristics of geological formations which indicate an ability to store and transmit water, e.g. purity of limestones, ability to fracture, dolomitisation.
- Hydrological indications of groundwater storage and movement.
- Information from boreholes, such as well yields, specific capacities (including the use of 'QSC Graphs', i.e. plots of well yield against specific capacity) and permeabilities from pumping tests.

Regionally important limestone aquifers are subdivided into three categories. Where karstification is slight, the limestones behave similarly to other fissured rocks and are classed as **Rf** (fissured), although some karst features may occur. Aquifers in which karstification is significant are classed as **Rk** (karst). Within the range represented by **Rk**, two sub-types are distinguished, termed $\mathbf{Rk^c}$ and $\mathbf{Rk^d}$. $\mathbf{Rk^c}$ are those aquifers in which the high degree of karstification limits the potential to develop groundwater. They have a high 'flashy' groundwater throughput, a large proportion of flow is concentrated in conduits, numerical modelling using conventional programs is not usually applicable, well yields are very variable with a high proportion having low or minimal yields, large springs are present, storage is low, locating areas of high permeability is difficult and therefore groundwater development using bored wells can be problematical. $\mathbf{Rk^d}$ aquifers are those in which flow is more diffuse, storage is higher, there are many high yielding wells, and development of bored wells is less difficult. These areas also have caves and large springs, but the springs have a more consistent flow.

A risk assessment approach is applied in the groundwater protection schemes undertaken in Ireland. In using this approach, the vulnerability of the groundwater, the value of the groundwater (in terms of aquifer category), and the hydrogeology of the aquifers (degree of karstification, for instance), are critical factors. Developments on regionally important karst aquifers pose a greater threat than on poor limestone aquifers; so there are more restrictions on development on the regionally important aquifers. Good conceptual models and a defensible categorisation of our aquifers are therefore essential elements in the groundwater protection scheme.

Source: Poster presented at and Abstract in Proceedings of a SEPM Research Conference, *Fluid Flow in Carbonates: Interdisciplinary Approaches*. Door County, Wisconsin, Sept. 20-24th, 1998.

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The Logan Method for Analysing Pumping Test Data

In the last GSI Groundwater Newsletter (No. 33, May 1998), Olga Aslibekian wrote an interesting article on transmissivities of Irish aquifers. She derived transmissivity values from well specific capacity data using a simplified version of the Thiem equation for steady radial flow in a confined aquifer. The well known Thiem equilibrium equation can be written as:

$$T = (2.3Q/2\pi s) \log r_e/r_w$$

where T = aquifer transmissivity, Q = well discharge rate, s = maximum well drawdown, r_e = radius of influence of the well, and r_w = well radius.

Olga's simplification involved elimination of the r_e term, which is generally unknown, from the equation by assuming that the well discharge equals the aquifer recharge within the cone of depression, and substituting to give:

$$T = (2.3q/2\pi) \log (1/r_w.\sqrt{Q/\pi\varepsilon})$$

where q = specific capacity and ε = groundwater recharge within the radius of influence of the well. The use of this equation therefore requires assumptions about the aquifer recharge rate and effective well radius, in addition to a specific capacity measurement.

I would like to mention an even simpler method of analysing specific capacity data for aquifer transmissivity. This method was described by Logan in the 1960s (he did not claim the method to be original), and it was included in the first edition of the pumping test analysis 'bible' by Kruseman and de Ridder, published in 1970. However, Logan's method has been omitted from the current (1990) edition of this book, and so it is perhaps less familiar to hydrogeologists nowadays.

In the Thiem equation, the ratio r_e/r_w cannot be determined accurately unless there is an extensive network of observation wells during the pumping test. Although this ratio may vary considerably, the log term is relatively insensitive to such variations. Logan (1964) proposed a value of 3.32 as 'typical' for this log ratio, and hence derived the following approximation of the Thiem equation:

$$T = 1.22\ Q/s$$

Similar approximations have been derived elsewhere. For example, Hunting Technical Services and Sir M MacDonald & Partners obtained the relationship T = 1.32 Q/s for well tests on alluvial aquifers in the Indus valley of Pakistan.

Strictly speaking, the Logan approximation given above only applies to confined aquifer conditions. Logan derived the following approximation for the unconfined case:

$$T = 2.43\ Qb/(s(2b-s))$$

where b = aquifer thickness.

Logan applied his approximation formulae to the results of ten pumping tests taken from the published literature: the transmissivities thus obtained ranged from +50% to -50% of the published values, with the errors being generally less than 10%. Therefore the Logan (or other similar) method can give a reasonable first estimate of transmissivity - provided that near-equilibrium conditions are achieved when the maximum drawdown is measured.

In addition to analysing specific capacity data from constant rate tests, the Logan formula can be applied to step test data in the form:

$$T = 1.22/B$$

where B is the formation loss 'constant' obtained from the intercept of the straight line in a plot of s/Q against Q, i.e. B is the specific drawdown value at zero well discharge. This analysis therefore provides an estimate of transmissivity after a correction for well losses.

A further application of this kind of relationship is in the estimation of the required

screen length when designing a well. In this case the T term is replaced by KL, where K = hydraulic conductivity and L = screen length. A factor of 1.5 or 2, rather than 1.22, is normally used to allow for well losses (see Clark, 1988), giving:

$$L = 2\,Q/(sK)$$

In conclusion, the Logan method provides a quick and simple means of analysing pumping test data. Even where sufficient test data are available to enable more sophisticated analyses (using the standard methods by Theis, Bolton, Jacob, etc.), the Logan method can be a useful check on the results: at the very least, its use should avoid the very large errors that can arise, for example, from the not uncommon practice of drawing a straight line through a non-linear data plot in a Jacob analysis.

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Bruce Misstear, Department of Civil, Structural and Environmental Engineering, TCD.

News on New Projects

Catchment Monitoring and Management Schemes for the Boyne, Suir and Liffey Catchments

The Department of the Environment and Local Government has inaugurated a series of Catchment Monitoring and Management Schemes. The three above-named catchment schemes have recently (8 September 1998) been started, with M.C. O'Sullivan as the lead contractor. In November a briefing meeting for interested parties in all three catchments was held in Trim, Co. Meath and the inaugural meetings of the Operational Management Committees for the three projects were held in Trim, Clonmel and Naas.

GSI has been invited to participate in the schemes because of the recognised importance of geological and hydrogeological factors in catchment hydrology and hydrochemistry. We shall be contributing appropriate data to the GIS system which is an important integral part of the schemes. GSI/Local Authority Groundwater Protection Schemes have been completed or are under way for major parts of all three catchments.

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South Cork Groundwater Protection Scheme

GSI and Cork County Council recently began work on a Groundwater Protection Scheme for the Southern Division of County Cork. Denise Kelly, fresh from the M.Sc. Hydrogeology course at University College London, has taken up the post of Project Hydrogeologist for the scheme.

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Geoff Wright, Geological Survey of Ireland

News from Abroad

Southern England River Water Quality
In the past two to three years there has been a sharp reduction in the chemical quality of rivers in southern England, after improvements in the early nineties. For instance, the river quality in the Thames region improved by a net 31% between 1990 and 1994, but there was a deterioration of 30% in the subsequent three years.

The downturn has been attributed mostly to the effects of lower rainfall and reduced flows on dilution of effluents and dissolved oxygen levels, although algal growth promoted by nutrient discharges and pressures on water resources are also considered to have played a part.
(Source: The ENDS Report, No. 282, July 1998)

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Britain: Increased Regulation of Sheep dip Operators and Facilities Proposed
The Environment Agency is proposing more comprehensive controls over sheep dipping to help prevent water pollution. this would include the extension of licensing to cover dip operators and facilities as well as dip disposal sites. Dipping is essential to control of parasites such as sheep scab, but disposal of spent dip is a growing source of water pollution with the number of waters failing environmental quality standards for sheep dip pesticides doubling since 1994. There were 34 dip pollution incidents in 1997 and 5% of all surface water samples analysed contained sheep dip chemicals. The main cause is the new generation of synthetic pyrethroid dips which, while less toxic to humans, are up to 100 times more toxic to aquatic life than organophosphates.

The Ministry of Agriculture's current good practice guidelines recommend disposing of spent dip by diluting it with water or slurry and spreading on level ground away from watercourses or wells. However this advice is based on the risks of organophosphate products and its suitability for pyrethroids has never been evaluated.
(Source: The ENDS Report, No. 282, July 1998)

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Wessex: Farmers Subsidised to Cut Nitrate Leaching

Wessex Water has become the first water company in Britain to offer farmers a subsidy to reduce nitrate leaching into groundwater. Nitrate levels are rising in 37 of Wessex's groundwater sources. Eight are predicted to breach the nitrate limit within 5-10 years if present farming practices continue. These sources produce 144 megalitres per day, 36% of the company's total resources. In a move designed to forestall expenditure on nitrate treatment, Wessex has announced that it will pay farmers in the affected areas a subsidy of up to £40 per hectare to adopt "more natural methods of farming". The scheme is to be administered by Soil Association, the Elm Farm Research Center and the Wiltshire Wildlife Trust.

The scheme is part financed through the landfill tax credits scheme, whereby waste companies can donate up to 20% of their landfill tax liabilities to approved environmental projects.
(Source: The ENDS Report, No. 279, April 1998)

Compiled by the Editor

IAH Congress 1998 "Gambling with Groundwater - Physical, Chemical, and Biological Aspects of Aquifer-Stream Relations" – A Review

The 28th IAH Congress entitled "Gambling with Groundwater - Physical, Chemical, and Biological Aspects of Aquifer-Stream Relations" was held in Las Vegas Nevada between the 28th September and the 2nd October 1998. I attended, along with about 300 hydrogeologists from all over the world.

The congress opened with four keynote presentations given by leading figures in the hydrogeological world.

William Woessner of the Dept. of Geology, University of Montana spoke about the broadening of hydrogeologists' views of stream-groundwater interaction as they interacted with other environmental specialists in mitigating an environmental challenge

John Lloyd of the University of Birmingham discussed the challenges which face the developing world where population increases and migration to urban centers is leading to water deficits. The need for integrated water supply schemes from a variety of sources coupled with population movement management were proposed as potential solutions.

Professor Traugott Scheytt from the Technical University of Berlin presented his research on the presence of drugs in groundwater, notably the blood lipid regulator clofibric acid. This pharmaceutical is found to be highly persistent, migrating through till layers to deeper aquifers. Groundwater contamination is likely to occur through leaky sewers among other sources.

Finally Patrick Leahy of the U.S.G.S. discussed the re-emergence and critical role of geological understanding in hydrogeology.

The keynote presentations were followed by concurrent technical sessions which were grouped under the following themes:

Contaminant Hydrology, Geology of Groundwater, Hazardous Waste and Water Quality, Hydrochemistry, Karst, Modelling, Protection and Conservation of Water Resources, Social, Political, and Legal Impacts and Surface Water/Groundwater Interaction and Wetlands.

There were also poster sessions presented by various organisations involved in hydrogeology.

The Congress was mainly attended by academics and government staff. There was a strong Irish presence, from both Irish hydrogeologists who are currently working in Ireland, and others who had migrated overseas. There was also a good presence of younger hydrogeologists, many of whom made presentations. The younger people were given a warm welcome particularly as the future of the IAH depends on them.

This was the first Congress I attended and I found it very worthwhile for a number of reasons. I really enjoyed meeting hydrogeologists from other parts of the world, some of whom I had met before through travel or were old friends from student days. It was also useful from a 'networking' point of view because I was on my way 'Down Under' to look for work and I made several good contacts in the hydrogeological world both in New Zealand and Australia.

I also attended one of the short courses in Applied Groundwater Modelling given by Waterloo Hydrologic prior to the Congress. Although it comprised a brief introduction to Visual MODFLOW, I found it a useful kick start in an area where I had little experience. It is already paying off as my first major project in my new position in Australia is groundwater modelling.

I also attended the one day post congress field trip to Death Valley which is a fascinating place.

Fionnuala Collins (now working in Australia)

Mine Water and Environmental Impacts: IMWA Symposium, Johannesburg, South Africa

This IMWA (International Mine Water Association) Symposium was held at the conference centre of The Wanderers Cricket Ground in the Johannesburg suburb of Sandton from 7 to 11 September 1998. It was attended by 73 participants from 23 countries. 42 papers from 15 countries were published in the proceedings, but owing to no-shows, only 31 papers were read, plus an impromptu presentation by Professor Rafael Fernandez-Rubio on the Los Frailes Tailings Dam failure. The attendance was somewhat disappointing, particularly as large regions of the world were unrepresented - participants were predominantly from South Africa itself, Australia, and a few European countries. Overall the standard of organisation and hospitality were very high.

Papers were presented on three days, while one day was given over to field excursions to the Western Deep Levels South Gold Mine or the Premier Diamond Mine, Cullinan. I presented a paper jointly authored with Ben Dhonau of the Exploration & Mining Division, Department of Marine & Natural Resources, entitled "Zinc-Lead Mines in Ireland: Approaches to Groundwater Control and Protection."

The Premier excursion was essentially a 'tourist trip' involving an audio-visual presentation, a view of the vast open pit, and a visit to their exhibition. The mine is currently down to 800 metres and they plan to go to at least 1200 metres. Premier's underground operation will involve block caving of about 100m thickness.

The post-symposium excursion was to the Palabora copper mine, in the northeast of the country - a very large, low grade (about 0.63%) deposit developed as an opencast mine but now being extended underground, where I was able to go down the two new shafts nearing completion at a depth of over 1200 metres below ground (c. 800 metres below sea level).

We had a good audio-visual presentation describing the history of the mine, which began in 1964. Besides copper, other minerals recovered at Palabora include magnetite, vermiculite, phosphate (apatite), uranium, zirconium, nickel, platinum, cadmium, palladium, gold and silver. Palabora also operates a separate vermiculite open pit close by, about 50 metres deep, and there is a separate phosphate development owned by another company (Foskor).

The open pit is about 2 km x 1.7 km across and over 700 metres deep. Current extraction is about 81,000 tonnes of ore per day. The ore is processed and smelted on site. The underground operation will access some 245 million tonnes of ore with an overall grade of 0.68% Cu, and an extraction rate of about 30,000 tonnes per day. There has been little or no water problem so far in the underground development.

The next IMWA symposium will be in Seville, Spain, in September 1999, on the theme of 'Mine Closure'. The excursions will include the area affected by the Los Frailes tailings disaster in April 1998, and the Nueve Corvo mine in southern Portugal.

The next (triennial) Congress will be in Katowice, Poland in 2000 (probably September).

Geoff Wright, Geological Survey of Ireland

IAH News

Technical Discussion Meetings: Programme for early 1999

5th January **Groundwater Contamination in Ireland: Some Facts – Some Fiction** by Marcus Ford, Dames & Moore
(This is the annual joint IAH/Geotechnical Society of Ireland meeting.)

2nd February The **Burdon Memorial Lecture** will be presented by **Dr Paul Younger**, of the Water Resources Group, Department of Civil Engineering, University of Newcastle, England. His theme will be **predictive modelling of hydrogeological problems resulting from the closure of deep mines**.

2nd March **Younger Hydrogeologists Forum**

These meetings are held in the GSI Lecture Theatre. They start at 18:00, with coffee/tea served at 17.30. For further information contact either Donal Daly (01-6041490) or Kevin Cullen (01-2941717)

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Annual Portlaoise Seminar

The annual seminar will be held on 20-21 April. The theme is **"Groundwater and Surface Water Interactions**". Further details will be circulated.

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New Committee

The IAH (Irish Group) held its AGM on 10 November 1998. Richard Church, who has done an excellent job as our Field Trip Secretary for the past two years, stepped down owing to work commitments, and we thank him for all he has done. Anita Furey has bravely agreed to take over the post, and we wish her every success. The current committee now comprises:

Geoff Wright	President
Bruce Misstear	Secretary
Margaret Keegan	Treasurer
Shane Bennet	Seminar Secretary
Anita Furey	Field Trip Secretary

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IAH Congress in Bratislava, Slovakia, Sept. 6-9, 1999

The 1999 IAH Congress is due to be held in the Slovak capital Bratislava. The topic is Hydrogeology and Land Use Management and the fee is US $350. Subthemes include legislative, developmental and protection aspects of groundwater management, with emphasis also on human health, groundwater and mining, and geothermal waters. One day and three day field trips are planned throughout Slovakia and to neighbouring Poland. Especially for those of you who have perhaps never been to an IAH Congress or never been to one of the new democracies in eastern Europe, then here is your chance! Slovakia is a beautiful mountain country with many interesting things to see, both scientific and cultural. It is very easy to reach since Vienna airport to Bratislava is less than one hour by car. For more information contact: Marian Fendek, the organisation secretary in the Slovak Geological Survey (Fax no. 00421754771940). Those of you who were at the 1998 Portlaoise meeting will remember he was our guest there.

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Irish Geological Heritage Theme 1 - Karst

This new programme in the Geological Survey is intended to select the very best of Irish karst for designation as Natural Heritage Areas, as its first theme. A network of sites will be chosen to exemplify the total karst heritage according to our current understanding. The work is being undertaken by contractors. A consortium led by CSA has been awarded the contract. Dr. John Kelly, who completed a comparable exercise in Northern Ireland, assessing the karst and cave heritage of Northern Ireland for the Department of Environment for their Earth Science Conservation Review; Dr. David Drew, Ireland's foremost karst expert and Gareth Ll. Jones, who has extensive and detailed knowledge of Irish karst. The team also comprises Morgan Burke, whose work building the GSI's karst database will be familiar to readers.

The key sites to be assessed for their potential NHA status have been selected in conjunction with GSI staff and an Expert Panel. This panel comprises: Dr. Mike Simms; who co-authored the Geological Conservation Review of Karst in Britain; Dr. Catherine Coxon, who brings a special expertise on turloughs, and Prof. John Gunn, Director of the Limestone Research Group in the University of Huddersfield.

The criteria to select potential NHAs are those of representativeness, uniqueness, and international importance. A minimum number of sites representing the typical karst features will be supplemented by the exceptional sites and those which have an international context. Turloughs are an obvious example of a karst feature that Ireland should be proud of maintaining, and which should not all be drained. However, karst is a natural system, and as far as possible integrity sites will be selected that, within an area, and within a dynamic system, contain many features of interest, rather than selecting single features e.g. a doline or a spring.

Perhaps of particular interest to Groundwater Newsletter readers is the greater awareness of, and integration of the hydrogeological aspects of karst into this selection process. With the rapidly developing field of karst hydrogeology this is a new direction, to the more geomorphologically based conservation schemes, such as in the UK.

If you wish to get further information on the programme, please contact me in the GSI at ☎ 01-6041493.

Matthew Parkes, Geological Survey of Ireland

CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

The GSI Groundwater Newsletter aims to improve communication among scientists and engineers involved in groundwater. It includes news, developments, reviews and opinions on all aspects of groundwater - exploration, development, management, water quality, pollution and energy. It is published 2-3 times each year.

Your contribution to the dialogue would be welcome. **Contributions for the next issue should arrive before 1st April 1999** to:

The Editor,
GSI Groundwater Newsletter,
Geological Survey of Ireland,
Beggars Bush,
Haddington Road,
Dublin 4.

Hydrogeological Links between Russia and Ireland

The Irish Group of the International Association of Hydrogeologists (IAH) has since 1995, forged strong links with the University of St. Petersburg following a visit from Professor Arkady Voronov of the Hydrogeology Department to Ireland. A number of Irish hydrogeologists visited the University in 1996. In September 1997 an eight member delegation of Russian hydrogeologists came to Ireland and visited Universities and Environmental organisations as well as attending workshops held in GSI. Five from this group then went on to attend the IAH Congress in Nottingham, England.

Ronan Murphy, the Irish Ambassador in Moscow and the Department of Foreign Affairs have strongly supported these Russian - Irish links and have backed them with some funding.

Last year GSI and ESBI sponsored two Russian Hydrogeology postgraduates to come to Ireland for work experience. Pavel Bezroukov spent three months working in the Groundwater Section compiling and interpreting hydrogeological and geotechnical information for Cork City. On return to St. Petersburg, he imported his work into MapInfo. During this period, Natasha Vinograd carried out hydrogeological consultancy work with ESBI.

In May 1998, a new Russian-Irish Cultural agreement was signed. The first part of this agreement deals with Education and Science and specifically mentions ongoing co-operation between St. Petersburg University, GSI and other Irish Institutions involved in hydrology. This year GSI sponsored Marina Barvich's work experience in Ireland. Marina worked in the Groundwater Section for one month and has recently returned to Russia. She is completing her studies for a PhD in Water Quality and Hydrochemistry in St. Petersburg. As part of her research Marina looked at concentrations of parameters such as Iron, Manganese, Chromium, Nickel, Cobalt, Barium, Iodine etc. in groundwater. She focused on whether these parameters are present in concentrations which have a significant impact on human health i.e. the biologically significant concentration (BSC). Marina has found that although the concentrations of some of these parameters are above the BSC, the groundwater in St. Petersburg is on the whole potable. As well as continuing her own research here she reviewed water quality data held in the Groundwater Section database.

Next March Professor Voronov plans to visit Ireland to discuss further co-operation including the running of a short English language hydrogeology course in St. Petersburg in the near future. This course will involve both Russian and Irish hydrogeologists and will further promote an exchange of ideas and experience on a wide range of issues.

Colette Cronin, Geological Survey of Ireland
