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THE GSI GROUNDWATER NEWSLETTER

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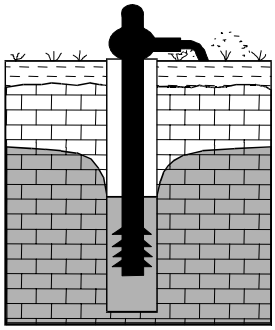

NUACHTAN SCREAMHUISCE SGE

- Taisceglaíocht
- Bainistíocht
- Truailliú
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- Athbhreithniú
- Tuairimí

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In This Issue

THE 10 COMMANDMENTS FOR HYDROGEOLOGISTS

1. Thou shall not assume isotropy, homogeneity, or uniform gradient without field evidence.
2. Thou shall not assume wells or streams to penetrate fully or flow systems to be two-dimensional.
3. Thou shall not use regional data to make site-specific judgements.
4. Thou shall not use colour graphics to enhance lousy science.
5. Thou shall not employ geostatistics to obfuscate poor interpretations or weak conclusions.
6. Thou shall not rely on stochastic methods to disguise insufficient field data.
7. Thou shall not place geochemical interpretations above hydraulic interpretations.
8. Thou shall never regard geophysics as the truth.
9. Thou shall never use a contouring program to make a water table map.
10. Thou shall never use more than three significant digits.

"***The Ten Hydrogeologic Commandments***" from the Directorate of Hydrogeology, Department of Water Affairs and Forestry, Republic of South Africa, Newsletter, Vol. 2, No. 1, January, 1998.

Groundwater Protection Responses for On-site Wastewater Systems for Single Houses.

Background

The Geological Survey of Ireland, Environmental Protection Agency and the Department of the Environment and Local Government have recently published *Groundwater Protection Responses for On-site Wastewater Systems for Single Houses* (GSI/EPA/DELG, 2001). These responses are the latest in a series of responses issued in conjunction with *Groundwater Protection Schemes* DELG/EPA/GSI, 1999.

The document is concerned with groundwater protection responses for the siting of on-site wastewater treatment systems for a dwelling house of up to 10 people with facilities for toilet usage, living, sleeping, bathing, cooking and eating. These responses are to be used in conjunction with the EPA guidance document *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000). The EPA guidance manual was prepared to provide guidance on the design, operation and maintenance of on-site wastewater treatment systems for a single house. The manual and the associated groundwater responses deal with both conventional septic tank systems and advanced treatment systems.

The groundwater protection responses outline which on-site wastewater treatment systems are acceptable in each groundwater protection zone (see matrix of zones in Table 1 from *Groundwater Protection Schemes* DELG/EPA/GSI, (1999)) and recommend conditions and/or investigations required depending on the vulnerability and aquifer type. The type and thickness of the soil and subsoil beneath the percolation area play a critical role in preventing groundwater contamination. In the case of a conventional septic tank system the soil and subsoil are considered to be very good and cost-effective media for treating and attenuating contaminants, provided that the hydrogeological conditions are suitable. In cases where the soil/subsoil conditions are such that it cannot accept the hydraulic loading applied then there will be a problem of surface ponding irrespective of what type of system is proposed.

Particular attention has been given to extremely vulnerable areas where requirements in addition to system selection, construction, operation and maintenance in accordance with EPA 2000 are necessary. Similarly additional protection has been afforded to the source protection areas of public water supplies and adjacent receptors at risk such as private wells and karst features.

When choosing the location and type of on-site system, developers should have regard to any nearby groundwater source, the groundwater resource and the vulnerability of the underlying groundwater. The groundwater protection responses combine these factors to produce a response matrix (see the following groundwater protection responses summary article).

Table 1 Matrix of Groundwater Protection Zones (DELG *et al*. 1999a)

VULNERABILITY	SOURCE PROTECTION		RESOURCE PROTECTION Aquifer Category						
			Regionally Imp.		Locally Imp.		Poor Aquifers		
RATING	*Inner*	*Outer*	*Rk*	*Rf/Rg*	*Lm/Lg*	*Ll*	*Pl*	*Pu*	
Extreme (E)	SI/E	SO/E	Rk/E	Rf/E	Lm/E	Ll/E	Pl/E	Pu/E	↓
High (H)	SI/H	SO/H	Rk/H	Rf/H	Lm/H	Ll/H	Pl/H	Pu/H	↓
Moderate (M)	SI/M	SO/M	Rk/M	Rf/M	Lm/M	Ll/M	Pl/M	Pu/M	↓
Low (L)	SI/L	SO/L	Rk/L	Rf/L	Lm/L	Ll/L	Pl/L	Pu/L	↓
	→	→	→	→	→	→	→	→	

(*In general, the arrows indicate directions of decreasing risk, with ↓ showing the decreasing likelihood of contamination and → showing the direction of decreasing consequence.)*

Effluent from On-site Wastewater Treatment Systems for Single Houses: A Potential Hazard for Groundwater

Domestic wastewater contains many substances that are undesirable and potentially harmful to human health and the environment. The most common contaminants of groundwater originating from on-site systems are pathogenic organisms and nitrate.

Pathogenic organisms

Pathogenic organisms can cause gasteroenteritis, polio, hepatitis, meningitis and eye infections. Organisms, such as *E. Coli*, *streptococci* and faecal coliforms, with the same enteric origin as the pathogens, are used to indicate whether pathogens may be present or not in wastewater.

Nitrogen

Nitrate in excess concentrations in water may constitute a risk to human health and the environment. Nitrogen enters on-site systems mainly as organic nitrogen, which means the nitrogen is part of a large biological molecule such as protein. Bacteria and other microbes oxidise or mineralise the organic nitrogen to ammonia, which is further oxidised to nitrites and nitrates.

Groundwater Protection Response Matrix for Single Houses

A risk assessment approach has been taken in the development of the response matrix. A precautionary approach is taken because of the variability of Irish subsoils, bedrock and the possibility that the treatment system may not function properly at all times.

The appropriate response to the risk of groundwater contamination from an on-site wastewater treatment system is given by the assigned response category (R) appropriate to each protection zone. The reader is directed to the full text of the Groundwater Protection Response for On-site Wastewater Systems for Single Houses for the response matrix and full details of the responses imposed.

In extremely vulnerable areas overlying locally important and poor aquifers particular attention should be given to the depth of soil/subsoil (minimum of 1.2 m) and steps taken to ensure that the likelihood of microbial pollution is minimised. These conditions also apply to highly vulnerable regionally important karstic aquifers. In the case of extremely vulnerable regionally important aquifers, the following are required:

(i) for conventional septic tank systems a minimum of 2 m of unsaturated soil/subsoil beneath the invert of the percolation trench; and

(ii) for advance systems a minimum of 1.2 m unsaturated soil/subsoil (T or P values 1 to 50)[1] beneath the invert of the polishing filter.

Additional thickness of soil/subsoil is required for both types of systems within the outer source protection areas as the risk is greater. In extremely vulnerable inner source protection areas conventional septic tanks are not allowed and a minimum of 1.8 m of unsaturated soil/subsoil (T or P values 1 to 50) beneath the invert of the polishing filter is required.

Other additional conditions include:

1) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.
2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.
3) A management and maintenance agreement is completed with the systems supplier

The responses assume that there is no significant groundwater contamination in the area and in areas where there are known nitrate or microbial contamination problems then more restrictive responses may be necessary. Ponding may occur in areas of low permeability subsoils (T >50) and thus safeguards for surface waters should be put in place.

Additional Requirements for the Location of On-site Treatment Systems Adjacent to Receptors at Risk, such as Wells and Karst Features

During the assessment of the suitability of the site for the development of an on-site system consideration should be given to the location of the percolation area with respect to adjacent receptors at risk. These features include water supply wells and springs (public and domestic) and karst features that enable the soil and subsoil to be

[1] The T value (expressed as min/25 mm) is the time taken for the water level to drop a specified distance in a percolation test hole. For shallow subsoils the test hole requirements are different and hence the test results are called P values. For further advice see page 25 of the EPA Manual (2000).

bypassed (e.g. swallow holes, collapse features). It has been recognised that in Ireland and elsewhere groundwater and wells have been contaminated by effluent from septic tanks therefore additional precautions are put in place for the location of the percolation area or polishing filter in the vicinity of receptors at risk. This is in line with the precautionary approach.

The responses provides recommended distances between receptors and percolation area or polishing filters, in order to protect groundwater. The depths and distances given are based on the concepts of 'risk assessment' and 'risk management', and take account, as far as practicable, of the uncertainties associated with hydrogeological conditions in Ireland.

Copies of this publication *Groundwater Protection Responses for On-site Wastewater Systems for Single Houses* (GSI/EPA/DELG, 2001) and *Groundwater Protection Schemes* DELG/EPA/GSI, 1999 are available from GSI public office, Government Publications Office and EPA Publications, St. Martin's House, Waterloo Road, Dublin 4.

Copies of *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000) are available from EPA Publications, St. Martin's House, Waterloo Road, Dublin 4.

Margaret Keegan, Environmental Protection Agency.

Groundwater Protection Responses for On-site Wastewater Systems for Single Houses

Summary

The potential suitability of a site for the development of an on-site system is assessed using the methodology outlined in *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000). The groundwater protection responses set out below should be used during the desk study assessment of a site to give an early indication of the suitability of a site for an on-site system. Information from the on-site assessment should be used to confirm or modify the response.

Response Matrix for On-site Treatment Systems

VULNERABILITY RATING	SOURCE PROTECTION AREA*		RESOURCE PROTECTION AREA Aquifer Category					
			Regionally Imp		*Locally Imp.*		*Poor Aquifers*	
	Inner (SI)	*Outer (SO)*	*Rk*	*Rf/Rg*	*Lm/Lg*	*Ll*	*Pl*	*Pu*
Extreme (E)	**R3[2]**	**R3[1]**	**R2[2]**	**R2[2]**	**R2[1]**	**R2[1]**	**R2[1]**	**R2[1]**
High (H)	**R2[4]**	**R2[3]**	**R2[1]**	**R1**	**R1**	**R1**	**R1**	**R1**
Moderate (M)	**R2[4]**	**R2[3]**	**R1**	**R1**	**R1**	**R1**	**R1**	**R1**
Low (L)	**R2[4]**	**R1**	**R1**	**R1**	**R1**	**R1**	**R1**	**R1**

- *For public, group scheme or industrial water supply sources where protection zones have not been delineated, the arbitrary distances given in DELG/EPA/GSI (1999) of 300 m for the Inner Protection Area (SI) and 1000 m for the Outer Protection Area (SO) should be used as a guide up-gradient of the source.*

R1 Acceptable subject to normal good practice (i.e. system selection, construction, operation and maintenance in accordance with EPA (2000).

R2[1] Acceptable subject to normal good practice. Where domestic water supplies are located nearby, particular attention should be given to the depth of subsoil over bedrock such that the minimum depths required (EPA, 2000) are met and that the likelihood of microbial pollution is minimised.

R2[2] Acceptable subject to normal good practice and the following additional condition:

1) There is a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench of a conventional septic tank system;

OR

1) A treatment system other than a conventional septic tank system as described in EPA (2000) is installed, with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values[1] from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2 m in total for a soil polishing filter).

R2[3] Acceptable subject to normal good practice, condition 1 above and the following additional condition:

2) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.

R2[4] Acceptable subject to normal good practice, conditions 1 and 2 above and the following additional condition:

3) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.

R3[1] Not generally acceptable, unless:

A conventional septic tank system is installed with a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench (i.e. an increase of 0.8 m from the EPA manual);

OR

A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2 m in total for a soil polishing filter).

and subject to the following conditions:

1) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.
2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.
3) A management and maintenance agreement is completed with the systems supplier.

R3[2] Not generally acceptable unless:

A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 1.2 m unsaturated soil/subsoil with P/T values from 1 to 50, (in addition to the polishing filter which should be a minimum depth of 0.6 m) beneath the invert of the polishing filter (i.e. 1.8 m in total for a soil polishing filter).

and subject to the following conditions

1) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.
2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.
3) A management and maintenance agreement is completed with the systems supplier.

Additional Requirements for the Location of On-site Treatment Systems Adjacent to Receptors at Risk, such as Wells and Karst Features

[1] The T value (expressed as min/25mm) is the time taken for the water level to drop a specified distance in a percolation test hole. For shallow subsoils the test hole requirements are different and hence the test results are called P values. For further advice see page 25 of the EPA Manual (2000).

Table 1 below provides recommended distances between receptors and percolation area or polishing filters, in order to protect groundwater. Use of the depths and distances in this table does not guarantee that pollution will not be caused; rather, it will reduce the risk of significant pollution occurring.

Table 1 Recommended Minimum Distance between a Receptor and a Percolation Area or Polishing Filter

T or P Value	**Type of soil/subsoil ***	**Depth of soil/subsoil (m) above bedrock (see note 1,2,3,6)**	**Minimum distance (m) from receptor to percolation area or polishing filter ******				
			Public Water Supply	***Karst feature***	***down-gradient domestic well* or *flow direction is unknown*** (see note 5)	***Domestic well alongside (no gradient)***	***up-gradient domestic well***
>30	CLAY; silty, sandy CLAY (e.g. clayey till); CLAY/SILT.	1.2 >3.0	60	15	40 30	25	15
10 -30	Sandy SILT; clayey, silty SAND; clayey, silty GRAVEL (e.g. sandy till).	1.2 >8.0	60	15	45 30	25	15
<10	SAND; GRAVEL; silty SAND.	2.0** 2.0*** >8.0***	60	15	60 40 30	25	15

* BS5930 descriptions
** water table 1.2-2.0 m
*** water table >2.0 m
**** The distance from the percolation area or polishing filter means the distance from the periphery of the percolation area or polishing filter and not the centre.

Notes:

1. Depths are measured from the invert level of the percolation trench.
2. Depths and distances can be related by interpolation: e.g. where the thickness of silty, sandy CLAY is 1.2 m, the minimum recommended distance from the well to percolation area is 40 m; where the thickness is 3.0 m, the distance is 30 m; distances for intermediate depths can be approximated by interpolation.
3. Where bedrock is shallow (<2 m below invert of the trench), greater distances may be necessary where there is evidence of the presence of preferential flow paths (e.g. cracks, roots) in the subsoil.
4. Where the minimum subsoil thicknesses are less than those given above, site improvements and systems other that conventional systems, as described in EPA (2000), may be used to reduce the likelihood of contamination.
5. If effluent and bacteria enter bedrock rapidly (within 1-2 days), the distances given may not be adequate where the percolation area is in the zone of contribution of a well. Further site specific evaluation is necessary.
6. Where bedrock is known to be karstified or highly fractured, greater depths of subsoil may be advisable to minimise the likelihood of contamination.

The Conventional Septic Tank and Percolation Area - the Sustainable (Relatively Speaking!) System for On-site Wastewater Treatment

Background

A public representative from a midland county recently told me that he believed that the use of septic tank systems should be banned and that only advanced systems should be used. Now he wasn't too knowledgeable about the technical aspects and clearly he had been influenced by the advertisements for advanced systems. I don't like disagreeing with public representatives, particularly when they have high positions in political parties. However, in as nice and diplomatic a way as I could, I told him I believed that he was wrong and that at least 50% of his county was suitable for the conventional septic system, provided they are sited and installed properly, i.e. using the *EPA Manual* (EPA, 2000). However, it is not only certain politicians who have this view; other people feel that the more technologically advanced systems should always be used. Are these attitudes justifiable? I suggest not. I admit that the proviso given above, i.e. **that conventional systems are installed properly**, is a major one and for some people will weaken my argument significantly. However, I believe that this problem can be overcome and that conventional septic tank systems should be regarded as the primary choice for householders and local authorities, with advanced systems used on sites not deemed suitable for conventional septic tank systems as indicated by the *EPA Manual* guidelines and the *Groundwater Protection Responses for On-site Systems* (DELG/EPA/GSI, 2001).

Some engineers and environmental health officers have a contrasting view and completely mistrust the use of advanced systems. They regard them as too complicated for domestic use, that they could break down, are used as a means of getting planning permission in 'undesirable' areas, are not monitored by regulatory authorities (unlike in some of the States in the US, where one researcher in this area told me he would not agree with their use unless there was a regulatory system in place for monitoring the systems), and are over-hyped.

It has struck me that it is necessary to find a balance between those that advocate only the use of advanced systems and those that completely disagree with using advanced systems. In fact, the *EPA Manual* and the *Groundwater Protection Response*s provide this balance. However, these documents are not yet generally used. This article is my attempt to discuss that balance. It also advocates the use of the *EPA Manual* and the *Groundwater Protection Responses* for decision-making in this area.

Why the Conventional Septic Tank System?

- The soil and subsoil are excellent and cost-effective media for treating and attenuating contaminants, provided the hydrogeological conditions are suitable. This is the basis for the successful use of conventional septic tank systems world-wide. The subsoils need to be sufficiently permeable to prevent ponding at the surface but not so permeable that effluent enters groundwater relatively untreated. Also, the subsoils need to be of a sufficient thickness so that the effluent does not enter bedrock too quickly with inadequate purification. This is the basis for the siting requirements in the *EPA Manual* and the *Groundwater Protection Responses*. These requirements take account of the latest research and understanding of flow and purification of effluent in the ground, and an improved site assessment procedure. (For instance, research was undertaken by Michael Rodgers and John Mulqueen at UCG specifically on on-site treatment systems for single houses, which was the basis for the *EPA Manual*. Also, the GSI has extensive experience on contamination of groundwater and wells.)

- There is no doubt but that there are large areas in Ireland with 'suitable' subsoil conditions where a properly installed system will use the 'ground' to adequately treat the effluent so that the risk to the environment and human health is minimal. For example, there are substantial areas with free-draining, moderately permeable subsoils (mainly tills/boulder clays) and highly permeable sand/gravel deposits with a thick unsaturated zone, both of which are suitable for conventional septic tank systems. In many counties, it is probable that over 50% of lowland areas are suitable.

- Conventional septic tank systems are the simplest and most basic of the systems allowed in the *EPA Manual*. They are based on gravity flow and use the available natural site conditions to a) treat the contaminants, b) dispose of the effluent and c) prevent

environmental and health impacts. No electricity is needed and there are no moving parts. They follow a seemingly well known engineering principle that I hadn't heard of until it was drummed into me by a county engineer - the KISS principle, 'keep it simple s….'. Therefore, in this era where the 'sustainable development' principle is part of our environmental policy, they are the most sustainable of the available approved systems, in my view. (Some advocates of 'real' alternative systems would argue that as their systems do not use water, their system is the sustainable system!)

Are there Disadvantages with Conventional Systems? Are there Solutions?

There can be no doubt but that groundwater and wells have been contaminated by effluent from conventional septic tank systems. In fact, septic tank systems are one of the main sources of bacteriological pollution of private wells (farmyards are the second main source). However, this situation reflects more on the inadequate construction and location of the systems, than on the system itself, in my view.

Assuming they are properly sited, following the site suitability assessment described in the *EPA Manual*, their main disadvantage relative to advanced systems is that the septic tank itself may not be constructed properly, might leak, might not be the right size or not have two chambers. However, there is a solution. Local authorities could require a 'competent' person, either one of their own staff or a consultant to certify that the work is undertaken properly. In particular, a watertightness test should have to be undertaken, as described in Section 4.1.3 of the *EPA Manual*.

A second significant disadvantage is that householders and builders might not install proper percolation areas, as local authorities do not have the staff resources to check sites afterwards. Once again, an obvious solution is to have the system 'certified' by, for instance, a reputable local engineering consultant or, if possible, by local authority staff.

Have the Advanced Systems a Role?

From the outset about a decade ago I have supported, in whatever way I could, the development and use of advanced systems. Advanced systems that are certified by the Agrément Board have important benefits:

- they are constructed and installed under the supervision of professional staff;
- they reduce the pollutant loading, relative to conventional septic tank systems;
- they can be used in areas that are not suitable for conventional systems.

By reducing the pollutant loading, the risk to groundwater and surface water is reduced. However, the effluent still has, or potentially could have, a significant pollutant loading, particularly in terms of bacteria and viruses. Also, clearly the hydraulic loading is not changed. Advanced systems have the further advantage that their design and installation is supported by the provision of long term maintenance contracts, which the system suppliers are prepared to offer. This gives the home-owner, and the local authority, a degree of confidence that the systems will operate properly, at least for the term of the maintenance contract.

Where are Advanced Systems the Best or Only Option?

This can be answered separately in terms of groundwater and surface water.

Groundwater

This is dealt with in the *Groundwater Protection Responses for On-site Systems* (see article in this Newsletter).

1. Advanced systems are the only type of system allowed in the SI/E groundwater protection zone, i.e., the Inner Source Protection Area (SI) around major groundwater sources (usually public and group scheme supplies), where the vulnerability is deemed to be 'extreme (E)'.
2. While the *Responses* allow both conventional and advanced systems in all other groundwater protection zones, I believe that as advanced systems reduce the pollutant loading, they are preferable in areas with shallow rock (i.e. where soil and subsoil are 0-2 m thick), particularly in areas with regionally important aquifers. The proportion of lowland areas underlain by regionally important bedrock aquifers, where the soil and subsoil thickness is <2 m cannot be calculated accurately at present, but could be ~10%, with the proportion varying from county to county. Counties like Clare and Roscommon would have a higher %.

Surface Water

This is dealt with in the *EPA Manual*.

Unless site improvements are feasible and undertaken, conventional septic tank systems cannot be used to dispose of sewage where the percolation test 'T' value is > 50. This applies to a significant proportion of the country. Advanced systems can be used in these areas, provided the P-test value is between 1-50. However, if it is planned to discharge to groundwater, care needs to be taken that the geological materials beneath the topsoil (where the P-test is carried out), while having a 'T' value >50, are sufficiently permeable to enable the effluent to flow away underground.

It is clear from this that advanced systems can play an important role in Ireland.

Other Related Points and Opinions

- S.R.6:1991 is seriously out of date and is ambiguous on some aspects. The sooner that the *EPA Manual* and the allied *Groundwater Protection Responses* become the guidance documents for locating on-site systems, the better for our groundwater, surface water and human health.
- There is no doubt that some people are/will not be happy and will quibble with aspects of these documents; in one instance I met an EHO that I know in the local supermarket on a Saturday morning (one of the downsides of being associated with septic tanks!!), who expressed disappointment with the EPA Manual. The main reason for this disappointment is that the *EPA Manual* and now the recently published *Groundwater Protection Responses* do not provide easy answers, while it can be argued that S.R.6 does. But, **there are no easy answers** for that proportion of the country where the soils, subsoils and hydrogeology do not provide optimum conditions for the disposal of sewage. Also, on some sites, people want to locate their source of water within 30-60 m of the area of their sewage disposal, thereby creating an inherently risky and complex situation. In all these areas, while the documents provide a framework for decision-making, the judgement of the site assessor will be a critical dimension to the proper design and location of on-site systems. This leaves a lot of responsibility with the site assessor.
- I would strongly recommend local authorities to use the Site Characterisation Form at the back of the *EPA Manual*. This is also available on the EPA website (http://www.epa.ie). A number of local authorities (e.g. Monaghan) are already doing so.

Main Conclusions

- Properly sited and installed conventional septic tank systems are the most sustainable of the approved systems.
- Proper installation of these systems can be assured if they are certified by a 'competent' person.
- Advanced systems have a major role to play in areas that are either less suitable or unsuitable for the conventional system,
- Advanced systems should not be regarded as the panacea for all on site wastewater problems.
- The *EPA Manual* and the *Groundwater Protection Responses for On-site Systems* need to be adopted as the guidance documents for the location of on-site systems for single houses.

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Donal Daly, Geological Survey of Ireland.

GROUNDWATER FOR A THIRSTY WORLD

Some Key Issues for the 21st Century

Summary of the Burdon Memorial Lecture 2001, IAH (Irish Group)

Groundwater in the World Water Vision
Major growth in the exploitation of groundwater resources in many developing nations has brought important benefits both to the rural community (including increased agricultural productivity and improved domestic well-being) and to the burgeoning urban population (since it has allowed the rapid expansion of relatively economical and secure water-supply). However, in numerous of the more water-stressed regions of the globe the rates of abstraction, coupled with some land-use and effluent disposal practices, are leading to marked degradation of the resource base itself, are bringing into question the sustainability of the associated development.

This lecture is based on recent major World Bank reviews of the sustainability of both urban and rural groundwater development, which provided important inputs to the World Water Forum of March 2000 and the associated WWC World Water Vision and GWP Framework for Action. Groundwater management is among the most important, least recognised and highly complex of natural resource challenges facing society. The lecture will describe the technical, institutional, legal and economic approaches that are being adopted in some recent initiatives.

The vision process identified an urgent need to promote more effective and integrated water resources management. As regards groundwater there are two challenges to overcome:

- (technical) - widespread inability to conceptualise the potential role of groundwater storage (often a major but undervalued asset) and to characterise aquifer systems adequately
- (institutional) – common inability to be proactive in controlling groundwater exploitation and constraining land-use for groundwater protection.

Amongst key institutional changes needed are improved definition of groundwater abstraction rights and tradability, mobilisation of the user-community in aquifer management, and progressive reduction or re-targeting of subsidies which distort natural economic constraints on groundwater use.

Water for Food Production & Rural Development
A world food security crisis is predicted within 15-25 years, due to continuing population growth, further losses of irrigated land through salinisation and continuing low crop yields in dryland farming. The importance of groundwater in irrigated agriculture gives rise to some critical questions:

- the significance to food production of current groundwater mining in major aquifers
- the threat to food production from rising water-tables and salinisation of soil and groundwater
- development of small groundwater supplies for supplementary irrigation of rainfed agriculture.

Amongst key technical actions needed where groundwater is important for irrigation are:

- demand management, through more efficient irrigation techniques and changes in crop type
- more effective conjunctive use of surface & groundwater
- more widespread artificial replenishment and water harvesting.
- reconciling groundwater use from shallow domestic wells with irrigation wells.

Water for Cities & Urban Development
Groundwater is a major source of potable water supply in many cities, while at the same time the subsurface receives an increasing volume of human and industrial waste. The potential linkages between urban services and groundwater need to be more widely understood.

Amongst key actions required to improve and rationalise groundwater management in urban areas are:

- groundwater use and contaminant load surveys, with identification of all significant stakeholders
- municipal planning to constrain groundwater abstraction and guide sanitation schemes
- using wastewater more effectively, either directly, or indirectly through aquifer recharge.

Challenges for the 21st Century

Groundwater Resources: from Exploitation to Management
Before the spread of post-war advances in well drilling and pump technology, groundwater abstraction was limited and by comparison resources appeared infinite. Governments often promoted exploitation, rather than management, and heavily subsidised well drilling and pumping,

making any subsequent constraints on groundwater use politically sensitive.

Competition for available groundwater can result in long-term water-level decline, often with quasi-irreversible side-effects. There also maybe social inequity where deeper, larger-capacity, irrigation wells lower the water-table and increase the cost of (or eliminate access to) water in shallow wells.

Regulatory agencies in developing nations are often under-resourced and weakly empowered in relation to groundwater abstraction control. However, increasing their budget and strengthening their powers will not necessarily improve the situation, unless certain inherent factors are also addressed:

- lack of awareness of the consequences of excessive exploitation and hence inadequate consensus (and thus political will) for action
- definition of groundwater abstraction rights, and thereby mobilisation of stakeholder participation
- uncertainty of resource evaluation due to inadequate monitoring of aquifer behaviour
- groundwater is generally undervalued, leading to economically inefficient allocation and use, and under-investment in water conservation and resource management.

Sustainable and optimised aquifer management must recognise and respect hydrogeologic and socio-economic diversity, but key components required to achieve these ends are:

- transformation of government organisations to enable them to facilitate the management process
- raising political and public awareness of the need for sustainable management
- development and application of groundwater resource decision-support systems
- assignment and consolidation of groundwater rights, and introducing realistic abstraction charges
- stimulation of stakeholder participation through the formation of aquifer-user associations
- breaking the common paradigm that aquifer recharge is a fixed, rather than variable with climatic cycles/changes and with modifications to surface water engineering and irrigated agriculture
- recognition of the interaction/interdependence between groundwater and surface water resources.

Groundwater Sources: from Development to Protection

Threats to groundwater quality are many and increasing, but examples of successful control are still rather few. Major persistent concerns are:

- the growing volume and complexity of contaminant loads, as a result of inadequate handling, disposal and re-use of wastewater
- the very widespread diffuse contaminant load due to leaching of agrochemicals and derivatives.

The need is to make real advances in protection through:

- identifying areas where aquifers are vulnerable to pollution due to insufficient intrinsic pollutant attenuation capacity, especially in the capture areas of major groundwater supply sources
- controlling the subsurface contaminant load in such areas by appropriate controls over land-use
- a more integrated approach to the management of groundwater and wastewater in urban areas.

Such actions will require justification in technical and economic terms.

Hydrogeological Science: Future Needs & Probable Trends

Pressures on groundwater resources will generate requirements and opportunities such as:

- tools for improved evaluation and prediction of groundwater interactions with surface water
- realistic valuation of groundwater resources, as a basis for more rational abstraction charging
- improved characterisation of groundwater storage, in relation to assessing the role of aquifers in conjunctive use or integrated management schemes and for drought preparedness
- improved understanding of subsurface biochemical processes determining the natural contaminant attenuation capacity of aquifers in their vadose and saturated zones.
- further development of natural and artificial tracer techniques to assess groundwater recharge rates and transit times, and vulnerability to contaminants.

Continued and accelerated development in hydrogeological data collection (field and remote) and processing (GIS-based) will provide important opportunities for research & practical application.

Hydrogeology is a relatively young, and inherently imprecise, science. Hydrogeologists still struggle to apply the growing knowledge-base effectively to the management of environmental resources and to improve public/political perception of groundwater. How well do we handle hydrogeological uncertainty and communicate risk, especially at the legal and financial interfaces? Current approaches range from exceedingly precautionary to widely optimistic. Some hydrogeologists dwell excessively on residual areas of uncertainty, while failing to clearly state what is known with confidence. This needs to be remedied to ensure that investment is directed towards water-supply protection rather than treatment, to the optimal use of groundwater storage rather than building more surface reservoirs, and to efficient subsurface waste disposal rather than more costly alternative solutions.

Stephen Foster, British Geological Survey.

David J Burdon (1914-87)

David Burdon was born in 1914 and educated at Clongowes Wood College, Dublin, UCD (BSc and BE) and Camborne School of Mines, Cornwall. After working in the Kolar Goldfield in South India for several years, he completed a PhD at Imperial College London on 'The geology of the southwestern part of the Leinster Granite' (1949).

In 1949 he began a distinguished career in Hydrogeology, beginning as water engineer and geologist to the Cyprus government. In 1952 he joined the UN Food & Agricultural Organisation (FAO), initially working in Syria and Jordan (1952-60), Greece (1960-63) and Egypt (1963-4), and later throughout the Middle East and Africa from FAO Headquarters in Rome. A prolific writer, David was a world authority on groundwater resources, especially in Karst areas, and in 1963 was awarded a DSc by the NUI.

In 1974 David retired from FAO and returned to the family home, Rathclare House in Buttevant, Co. Cork. From then until his death in December 1987 he encompassed many activities – numerous consultancy tasks for FAO and other UN agencies, consultant to the GSI, director of Minerex Ltd, visiting lecturer and external examiner at several Irish and UK 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 IAH, which began at the 19th International Geological Congress at Algiers in 1952, and was made an Honorary Member in 1986. He was founder President of the Irish Group (1976-83). The IAH established in David's honour the Burdon Commission on Hydrogeology in Developing Countries, and the Burdon Fund, which assists hydrogeologists from those countries.

Many of us knew David also as a family man, and as an entertaining and hospitable host. Above all, we remember him as our great encourager, rejoicing in discussion and debate, always having time in his busy life for anyone wanting advice or comment upon some idea or draft report. David's extensive personal library was kindly bequeathed to the Irish IAH Group and is housed and maintained by the GSI.

Geoff Wright, Geological Survey of Ireland.

IAH (Irish Group) News

Technical Discussion Meetings & IAH Programme for Autumn/Winter 2001

6th November ***The Groundwater Protection Responses for On-site Wastewater Treatment Systems*** by Donal Daly (GSI) and Margaret Keegan (EPA)

4th December ***Water Tracing*** by David Drew

8th January Joint annual Geotechnical Society of Ireland/IAH (Irish Group) meeting. Presentation by Paul Johnston, TCD. This meeting will take place at the IEI, 22 Clyde Road, Dublin 4.

The November and December meetings will take place at the GSI Lecture Theatre, Haddington Road, Dublin 4. They start at 18:00hrs, with tea/coffee served at 17:30hrs. For further information, please contact either Donal Daly (01- 6041490) or Kevin Cullen (01 – 294 1717).

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IAH Congress in Munich, Germany, 10th to 14th September 2001

The 2001 IAH Congress was held in Munich, Germany. The topic was "New Approaches to characterising groundwater flow".

*****

Annual Fieldtrip

This year's fieldtrip was held in Co. Clare, on 29th and 30th September. The trip focused on the "Hydrogeological aspects of the Burren" and was lead by Dr. David Drew. Over thirty people in all took part and the field trip proved to be an enjoyable and illuminating experience.

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Annual Seminar

This year marks the 21st anniversary of the IAH (Irish Group) annual seminar. This year, the seminar will be held on 16th and 17th October 2001 in the **Tullamore Court Hotel** in **Tullamore, Co. Offaly**. **Please note the change from the usual venue**. The theme of the seminar is "**Gravel Aquifers – investigation, development and protection**". For more details, please contact the secretary or conference secretary below:

Anita Furey email: anita.furey@pjtobin.ie
phone: 091 – 56 52 11
Malcolm Doak email: m.doak@epa.ie
phone: 053 – 47 120

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Anita Furey, IAH Secretary (Irish Group).

Directory of Active Quarries, Pits and Mines in Ireland – 2001

The third edition of the Quarry Directory – ***Directory of Active Quarries, Pits and Mines in Ireland, 2001*** - has been completed and is now available. This edition follows the successful publication of the first edition in 1986 and the second edition in 1994. The quarry directory has a wide range of users including planners, economists, engineers, geologists, sales representatives as well as consumers and producers of natural stone material.

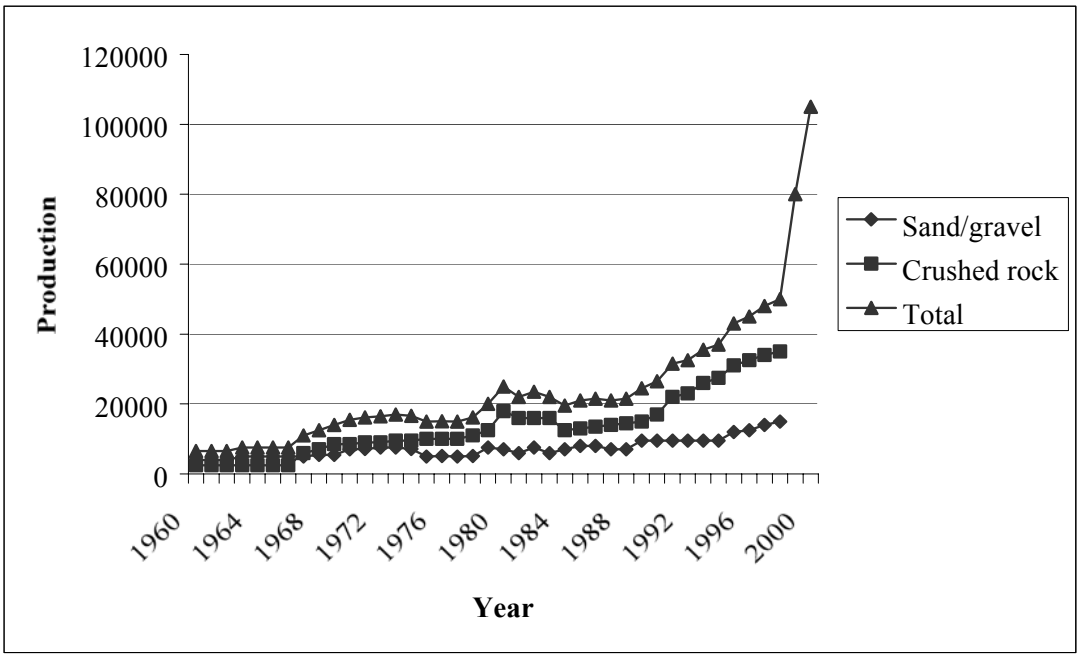
The Directory is available both as hard copy and on CD. This is the first time that this information has been made available on CD. The CD is structured in such as way that it will automatically start up. The information can be searched by the name of the quarry or by county. We hope customers will enjoy this new product. The hard copy and CD cost £25 each or both are available at a combined price of £40.

This new edition contains 415 entries as compared with 196 in the previous edition. This increase reflects both a significant increase in the number of active quarries but also reflects the methodologies adopted in collecting the data. For this edition quarries were contacted by post, phone and finally visited in order to obtain details.

Information on each of the quarries/pits includes: Quarry name, address, contact name and contact details, operator, rock type, production and products.

It is estimated that production of sand/gravel and crushed rock is now approximately 100 million tonnes (Figure 1).

Figure 1. Aggregate Production in the Republic of Ireland.



The Geological Survey of Ireland would like to thank all those who contributed.

Eibhlín Doyle, PGeo, Minerals Section, Geological Survey of Ireland.

IGI (Institute of Geologists of Ireland) News

AGM 2001
The following Board members were elected at the IGI AGM on 15th May 2001:

Name	*Position*	*Term*
John Clifford	President	Two years
Peter O'Connor	Treasurer	Two years
Andy Bowden	Ordinary Member	One year
Becci Cantrell	Ordinary Member	One year
Teri Hayes	Ordinary Member	One year
Gareth Ll. Jones	Ordinary Member	One year
John Morris	Ordinary Member	One year
Christian Schaffalitzky	Ordinary Member	One year

Eugene Daly and Julian Menuge continue in their respective positions of Vice-President and Secretary for another year. Colm Molloy has joined the Board as an observer for the IEI Geotechnical Society whilst Gerry Stanley, Morgan Burke and Piers Gardiner continue as observers for the IAEG, IAH and IMQS, respectively. Two new Working Groups have been established by the new Board: John Morris will chair the Communications and Web Site Working Group and John Clifford will chair the Strategy Development Working Group, which aims to set longer term goals for the IGI.

New Members
Floriano Villa and Mark Conroy have been elected to Professional Membership of the IGI, whilst Floriano was also elected to the title of EurGeol. at the June EFG Council meeting in Cracow.

IGI Directory
The Members Directory for 2001 was launched by Minister Joe Jacob on the 29th May and will be distributed to IGI Members, Government Departments, Local Authorities, Consulting Engineers, Mining Companies and other users of geological services.

In his speech the Minister recognised the value of geology. The full text of the Minister's speech and the Directory are available on the IGI web site.

Exploration & Mining Division Reporting Requirement
At the inauguration of the IGI in May 1999, the then Minister for the Marine and Natural Resources, Dr Michael Woods T.D., signaled that the Exploration and Mining Division (EMD) of his Department would in due course be requiring that reports lodged under the requirements of Prospecting Licences would only be accepted if signed by a suitably 'qualified person'. The EMD has now proposed that from 1st January 2002, all geological reports lodged in connection with exploration must be signed by a 'qualified person'.

All reports submitted after 1st January 2002 will be required to include a standard form which provides the relevant qualifications (with dates) and signature of the author, or of the suitably professionally qualified individual who is responsible for endorsing and signing off the work. The professional area of expertise is also required, to show its relevance to the subject of the report.

The IGI welcomes this development as a step in increasing professional standards and will be actively encouraging other regulatory bodies to adopt a similar approach.

Courses
Two successful IGI-accredited one-day courses have recently been held in Dublin. 'Effective Use of Geophysical Methods in Ground Investigation', organised by the GAI and the Geotechnical Society, was held on 23rd May and 'Fundamentals of Project Management', arranged through the IEI, was held on 13th June. A programme of courses for the period up to the next IGI AGM is currently under construction, in consultation with the IGI's Sponsoring Bodies.

The European Code for the Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves
Following the review and incorporation of extensive commentary resulting from the consultation process, the Code has been further revised. This latest revision was completed during the recent IAEG Conference on Reserves and Resources in Waterford. During that meeting the opportunity was taken to review details of the Code with Mr. Pat Stephenson, Chairman of the Joint Ore Reserves Committee (JORC).

The Code has been prepared by a Working Group with membership from The European Federation of Geologists, The Geological Society, The Institute of Geologists of Ireland and The Institution of Mining and Metallurgy. The Code has been approved by the IMM and EFG Councils and by the Board of the IGI. A copy of the revised Code can be viewed on the IGI web site.

Mutual Recognition Agreement with the Geological Society

The IGI and the Geological Society have agreed to recognise each other's professional qualifications (PGeo and CGeol, respectively). A professional member of one organisation may now apply for professional membership of the other with a single supporting letter from the first organisation, in lieu of letters from individual sponsors, and without the need for interview. The IGI and Geological Society will offer participation in each other's courses at the members' rate and recognise each other's courses for CPD purposes. The Geological Society has also agreed to make its publications available to IGI members at the same prices as are charged to their own members.

Mutual Recognition Agreements with Other Bodies

The IGI has opened discussion with the AusIMM on mutual recognition of professional titles.

European Federation of Geologists – Relaunch of the EurGeol Title

The EFG at its Council Meeting in Cracow in June 2001 approved a proposal presented by the IGI, as Chair of the Working Group, for national associations to be licensed to award the EurGeol. title. It is intended that the IGI will formally lodge an application to be licensed in early July, with effect if approved from January 2002.

The implications of this for the IGI will be a reduction of 30% in the affiliation fee and development of a new revenue stream estimated at approximately 300 Euros. The implication for IGI members is that all current holders of the PGeo title who do not hold the EurGeol. title will be entitled to a once-off offer of the EurGeol. title by payment of a 15 Euros annual fee.

EurGeol. Title Recognition

Mr. Gerard Collins MEP placed a question in the European Parliament for answer by the European Commission. The question on mobility to practice for geologists within the EU was drafted by a Working Group chaired by the IGI.

The question was posed as follows:

The European Federation of Geologists ("EFG") is a federation comprising 20 national geological associations in Europe, including those from all of the member states within the European Union.

Geological science is a rapidly changing discipline. The activity of geoscientists impinges in an ever-increasing way upon the safety of the public. Educational and training provisions need to adapt accordingly to respond to those changes. For its part, a professional qualifying body in geoscience needs to be vigilant in assuring qualifying standards in its own field. At the European level, the EFG is that body.

Pursuant to Directive 89/48/EEC (OJ L 9.24.1.1989, p.16) and Directive 92/51/EEC (OJ L 209.24.7.1992, p.25) the EFG has adopted a system of multi-lateral recognition between the affiliated geological associations. Candidates who meet the requirements are awarded the professional title of European Geologist (EurGeol.). Award of the designation signals the preparedness of the EFG to assure the qualifications of those who practice at the highest levels in all areas of the geosciences. Holders of the title must comply with the EFG's Code of Professional Conduct.

A candidate for the title must have satisfactorily completed a third level educational program and obtained satisfactory professional experience over a combined minimum total of eight years. The requirements are thus higher than the requirements laid down in the General Directive. Applicants for registration must be recommended by their National Association and accepted by the EFG Validation Committee before obtaining the EurGeol. title.

The aim of the EurGeol. designation is to; a) recognise the practice of geoscience at a high level; b) set unambiguously clear and high standards that are recognisable by government, regulatory authority and the public alike; and c) facilitate free movement of geologists within the European Union by means of mutual recognition of professional qualifications.

Does the Commission support this kind of initiative as a way of facilitating the

free movement of professionals in the EU?

To what extent could the EurGeol. title facilitate the recognition of national qualifications among Member States?

The Commission in a reply given by Mr. Bolkestin (16 March 2001) stated that:

The Commission has been informed of the existence of the title of "European Geologist" created by the European Federation of Geologists (EFG).

Although this title does not amount to a "diploma" within the meaning of Council Directive 89/48/EEC of 21 December 1988 on a general system for recognition of higher education diplomas awarded on completion of professional education and training of at least three years' duration, and Council Directive 92/51/EEC of 18 June 1992 on a second general system for the recognition of professional education and training to supplement Directive 89/48/EEC[(1)], the Commission fully supports this move by the EFG, since it is likely to facilitate free movement of geologists within the Community.

On the one hand, the title of "European Geologist" can be useful both to the national authorities entrusted with examining applications for the recognition of qualifications and diplomas acquired in another Member State, and to potential employers who have to assess the qualifications of candidates in possession of foreign diplomas.

On the other hand, in view of the criteria for awarding the title of "European Geologist", possession of that title is evidence of a high level of competence regardless of the initial academic training of the professional concerned. In so far as, by virtue of the case law of the Court of Justice[(2)], the Member States must take account of the professional experience acquired by the migrant in addition to his diploma, when deciding on his application for recognition, the Commission considers that a geologist who has obtained the title of "European Geologist" should in principle not have to take an aptitude test or complete an adaptation period pursuant to Article 4 of the Directive 89/48/EEC or Article 7 of Directive 92/51/EEC.

Finally, in its Communication of 7 February 2001 entitled "Realisation of the European Union's potential: Consolidating and extending the Lisbon strategy"[(3)], the Commission announced that it would be presenting, in 2002, proposals aimed at making the rules on recognition of professional qualifications more uniform, more transparent and more flexible. Whilst based on the current general system for recognition, more systematic involvement of the professional organisations and encouragement for the development of common platforms such as the one set up by the EFG should ensure a greater measure of automatic recognition of professional qualifications within the Community.

References

(1) OJ L 19 of 24.1.1989

(2) Case C-340/89, Vlassopoulou, ECR I-2357

(3) Doc, COM(2001) 79, followed by a second Communication adopted by the Commission on 28 February 2001 and entitled "New European Labour Markets, Open to All, with Access for All"

The IGI web site address is www.igi.ie

Dr Julian Menuge, PGeo, IGI Hon. Secretary.

The Karst of Ireland – A New Publication

A 37 page A4 booklet, in full colour, entitled ***The Karst of Ireland: Limestone Landscapes, Caves, and Groundwater Drainage System*** was published earlier this year. 'Karst' is the term used world-wide to describe the distinctive landforms that develop where rocks are dissolved by water. The solution of limestones by water in Ireland over millions of years has resulted in the distinctive landscapes of the Burren (the term 'Burren' derives from the Gaelic for 'stony place') and the Cuilcagh mountains; the well known caves at Mitchelstown and Marble Arch; important and beautiful wetlands, such as the turloughs in the Gort-Kinvara area; and unusual features such as swallow holes and sinking streams.

Half of Ireland is underlain by limestones, which can dissolve slowly in water, even though most people may not be aware of this as the limestone is covered in many areas by a thin veneer of glacial boulder clay, sand, gravel and peat. So karst can have a significant impact on many people in Ireland. Perhaps the most obvious impact is karst as a distinctive landscape, enhancing the beauty of Ireland, adding to the enjoyment and appreciation of nature, and providing tourism potential. While the surreal landscape of the Burren is perhaps the best known upland karst area in Ireland, Ben Bulben, the Cuilcagh Mountains and Bricklieve mountains are all scenic karst areas. Lowland karsts also have many examples of dramatic features and scenery, including the Rock of Cashel, the Rock of Dunamase, the Aran Islands, the shore of Lough Leane, the Antrim coast and the turloughs in the Gort-Kinvara area. Where solution enlarges tiny cracks in the limestone over millions of years into large cavities, we get the mystery and beauty of caves. The magical underground scenery of show caves, such as Marble Arch (Fermanagh), Mitchelstown (Tipperary) and Aillwee (Clare), are an attraction for tourists and an underground laboratory for students.

About 20% of our drinking water comes from karst limestones, including most of our large springs. Unfortunately karst areas are also particularly vulnerable to pollution, because contaminants can move rapidly through fissures widened by solution. A pollution incident in one place may affect a public or private water supply many miles away, as the conduits and fissures in the limestone may transmit the water in days or even hours. Karst is also important in civil engineering projects. Roads, bridges, tunnels, pipelines, mining or building may encounter special problems in karst areas, with their irregular bedrock surface, underground cavities and rapid drainage. A distinctive ecology often develops on karst areas, including the flora of the Burren and turloughs, several of which are of international importance.

The booklet explains what karst is and how it forms, describes the karst in different areas and the practical ways in which karst is important to everyday life, and advocates the need for conservation of our karst heritage. As the booklet says *"The more the public wants and supports nature conservation, the easier it will be to achieve it. The concept of conservation can only be viable when it takes firm root in public opinion. Therefore it is essential to see local people as partners/stakeholders in karst conservation. The implication of this is that priority must be given to publicity and education. This booklet is part of the process"*. It is produced and published by the Karst Working Group – an informal group representing the Geological Survey of Ireland (GSI), the Irish Group of the International Association of Hydrogeologists (IAH), the Geotechnical Society of Ireland and the Irish Association for Economic Geology (IAEG).

The booklet is intended to generate awareness of the importance of karst. Thanks to the generosity of many sponsors, the booklet has been distributed free to every second level school and public library in Ireland, and all relevant third level departments and public bodies. It was also sent to all local authorities. If you would like a copy, contact Jennifer Cullen, GSI, at 01 6782781 or jennifercullen@gsi.ie.

This publication is also available on the GSI webpage: **http://www.gsi.ie/workgsi/groundwater/karstbook**

Donal Daly, Working Group Secretary, c/o Geological Survey of Ireland.

Other recent publications of interest on karst

Newly available is an excellent book ***Beneath our Feet. The Caves and Limestone Scenery of the North of Ireland***. Written by Pam and Tim Fogg, it is published by the Environment and Heritage Service. It derives from the Earth Science Conservation Review of Karst sites in Northern Ireland, but is entirely non-technical. This book occupies the same general territory as the Karst of Ireland booklet recently published by the Karst Working Group of Ireland, but is complementary to it rather than equivalent. In my opinion, it succeeds even more, in the ambitions and intentions of getting across a fascinating but poorly understood important facet of the landscape. It is beautifully illustrated in colour with the authors' own photographs of examples throughout Northern Ireland, primarily Fermanagh and Antrim. Their detailed knowledge and love of the caves and karst is clearly apparent in the text and illustrations which explain karst phenomena in a clear and accessible manner. If you want to expand your own grasp of karst hydrogeology, or just see photographs of good examples of features then I recommend this book. Available from bookshops and from various outlets in NI; from Corporate Document Services, The Studios, 89 Holywood Road, Belfast, BT4 3BD or from orderline@corpdocs.co.uk at Sterling £10.00. Alternatively, you can order it from Geoscapes, 3 Fontenoy Street, Dublin 7 for IR£12.50 plus £1.80 postage.

A second fine addition to the range of books on karst in Ireland is that by Mike Simms, published by burrenkarst.com: ***Exploring the limestone landscapes of the Burren and the Gort Lowlands***. This is a guide for walkers, cyclists and motorists, in a handy 64 page A5 size in full colour. The first 25 pages cover similar territory to the book above and explains basic concepts and processes of karst in general, and the Clare – Galway region in particular. The remainder of the book is given over to 7 main excursions, with numerous individual places along the routes described and often illustrated, clearly based on deep personal knowledge of the landscapes. Excursion maps allow any combination of sites to be visited, and there is a useful glossary. This is highly recommended for any limestone or Burren enthusiast, and for those who aren't yet it should be a great encouragement! Available from Burrenkarst.com at Eden House, Belfast, BT8 8JY for Sterling £6.00 or from Geoscapes, 3 Fontenoy Street, Dublin 7 for IR£7.50 plus 70p postage.

Matthew Parkes, Geological Survey of Ireland.

People in the News: *Richard Thorn*

Many readers of the Groundwater Newsletter will either know or know of Richard Thorn. He was very active in the 80s and early 90s on groundwater issues such as karst, nitrates, septic tank systems and groundwater protection, and made a major input in these areas. During that time he was a lecturer at Sligo RTC, and over time became Director of Research, Head of R&D and, finally, Acting Head of the Department of Environmental Science. He was one of the regular contributors to the Newsletter. Since 1994 we haven't heard too much from him because he became Head of Campus at Galway-Mayo Institute of Technology (GMIT) and later became responsible for Letterfrack Furniture College which is a campus of GMIT. Earlier this year, he was appointed as the new Director of the Institute of Technology Sligo. This is a major achievement for Richard; it gives satisfaction to those that know him; and so we congratulate him and wish him continued success.

Donal Daly, Geological Survey of Ireland

Review

Pesticides in Groundwater of the United States, 1992-1996

By Dana W. Kolpin, Jack E. Barbash and Robert J. Gilliom
GROUND WATER 38, No. 6: 858-863

IN 1992, the U.S. Geological Survey began its National Water Quality Assessment with the objective to test the quality of groundwater in the country's main hydrological basins. In the first phase of the project, which spanned from 1992 to 1996, over two thousand groundwater sites were tested for up to 90 different types of pesticide and degradate. The results obtained from this initial stage of the undertaking are presented in this paper.

Almost half of the tested sites (48.4%) showed signs of contamination by pesticides. Results showed that mixtures of pesticides were more commonly detected than individual pesticides. In some cases, up to six different pesticides were present, with thirteen pesticides found in one particular sample. A combination of certain pesticides can pose a threat to both human health and to the environment and so the paper suggests that future research into pesticides and their effects should consider the consequences of pesticide mixtures.

The study emphasised the fact that although agricultural use of land has always been associated with the presence of pesticides in groundwater, urban land use could also be responsible for the contamination of groundwater by pesticides. Of course, the pesticides detected in both cases differed. It is also possible that pesticides contained in groundwater originated in ways other than that of recent chemical use. Atmospheric deposition, previous activities and the movement of pesticide from the surrounding area by way of runoff or subsoil movement can all result in the occurrence of pesticides in water. Despite this the results showed that the likelihood of detecting pesticides was increased in areas where land was used in an agricultural manner within 1km of the test site.

During the study a number of factors needed to be taken into consideration such as the ability of a pesticide to move through the subsoil and its capacity to exist under any prevailing environmental conditions. The degree to which the pesticide is used is a dominant factor in its detection while soil properties, hydrogeological conditions, the age of the groundwater and land use management practices are also important.

The main conclusions that can be taken from the paper are as follows: Pesticides are commonly found in groundwater with pesticide mixtures dominating. They can be associated with a number of activities but mainly those of an agricultural or urban nature. The persistence of a pesticide is reliant on a number of variables including the pesticide itself and its surrounding environment. The paper also questions the suitability of current U.S. health standards for groundwater where pesticide mixtures are concerned and recommends that any research in the future should take these mixtures into consideration.

Jane Healy, Geological Survey of Ireland.

Review

Fingering in Unsaturated Zone Flow:

A Qualitative Review with Laboratory Experiments on Heterogeneous Systems

By Oliver T.N. Sililo and John H. Tellam.

GROUND WATER 38, No. 6: 864-871

Introduction:

Most rocks are heterogeneous as a result of natural variations during their formations and subsequent alteration. Thus in highly heterogeneous soil structures, flow in the unsaturated zone can be very complex. Water can travel rapidly through preferential flowpaths named macropores, such as cracks, burrows and soil pipes. However, over the past ten years research has been carried out on another class of preferential flowpaths: those occurring in macroporeless soils caused by fingering. Fingering can be described as a process that causes preferential pathways in macroporeless soils by instability at the wetting front. The preferential flowpaths caused by fingering are transient and are dependent on a variety of properties, namely, grain size and structure, infiltration flux and the initial boundary conditions.

Determination of the flow in the unsaturated zone is significant in: **a)** determining the amount and timing of recharge, **b)** determining the quantities and timing of pollutant transfer to the water table, and **c)** determining pore pressure distribution for engineering measurements. Thus the unstable and unpredictable nature of the fingering process in the unsaturated zone is an important one and should be taken into consideration when dealing with all surface water/groundwater interactions. From the literature, evidence abounds suggesting the non-uniform transport and rapid transfer of water from the ground to aquifers in macroporeless soils. This evidence can be observed after a rainfall event when rapid changes occur in the water level and the chemical composition of the water (Steenhuis *et al*. 1996) and also when recharge occurs even when evapo-transpiration is high (Beekman *at al.* 1996).

Experimental Procedure:

The experiments were conducted in laboratory tanks made from transparent plastic plates (50cm x 50xm x 2cm) which were filled with sand. Plexi-glass separated the front and back at the edges of the tank. The base of the tank had a brass plate with several holes of 2mm diameter covered by mesh. The bottom of the chamber was divided into five units. The front and sides of the chamber had several small holes to let air escape freely, yet were small enough to prevent sand from falling through. Potassium permanganate was used as a tracer. The wetting front was monitored on one side and photographs were taken every few seconds.

Conclusion:

Generally, the laboratory experiments have shown that the overall effect of heterogeneities to is make fingers more irregular, with the percentage of flow increasing through certain fingers in relation to others. Certain combinations of heterogeneities might work together to enhance or hinder the formation of finger structures. Fingering will be enhanced in initially dry, layered coarse-grained systems, especially where structures that focus flow are present. Factors that suppress fingering include antecedent moisture content, small permeability contrast between an upper fine-grained layer and a lower coarse-grained layer, and presence of perched water bodies.

In conclusion, fingers may be viewed as semi-permanent preferential flow structures that can transport water rapidly both spatially and temporally. It should be noted that once formed, fingers can remain in the same locations for a long time. Fingering is an important mechanism to be considered when dealing with flow in the unsaturated zone. Hydrogeological applications such as recharge estimation, interpretation of hydrochemical data, the monitoring, transportation and fate of contaminants and groundwater pollutants are all effected by fingering as fingering induces preferential flow in the soil, by which pesticides and other contaminants are transported much faster.

Table 1: Showing results for eight experiments carried out under different heterogeneous systems.

	Type of heterogeneous	

Experiment	system	Result
1	Flow from a fine-grained to a coarse-grained layer	Results show that the maximum finger diameter that can develop decreases with increasing grain size. Coarse-grained sands are inclined to develop thinner, fewer and more widely spaced fingers than finer-grained sands. Increasing the flow rate reduces the finger spacing, which in turn increases finger density.
2	Flow through a multi layered system	Stratification enhances the process of fingering.
3	Flow through a discontinuous layered system	Both fingering and funnelling will occur. Funnelling is caused by changes in the permeability structure of a soil.
4	Flow through a dipping multi layered system	Lateral flow on top of the fine-grained layers will increase the flux in the down-dip direction. The latter will dominate flow in the system because water will be received from both the lateral and vertical directions.
5	Flow through a system with undulating layers	Surface depressions will concentrate water flow, and fingers forming below such areas will dominate the flow in the systems.
6	Flow through layers of variable thickness	In systems where the top fine-grained layer has a variable thickness, finger density and amount of flow will be greatest at zones where the fine layer is thinner.
7	Recommencement of flow after a period of no flow	Fingers reformed in the same place as previously, this is because during rewetting, water will first penetrate the coarse grained layer where there is a high moisture content (at the previous finger zones)
8	Other experiments	In moist sands, fingers will be broader and less distinct

Debbie Williams, Geological Survey of Ireland.

Conference Notice

"Natural and cultural landscapes: the geological foundation"

This conference, to be held in Dublin, Ireland in September 2002 will examine the critical inter-relationship between the geological realm and other components of the natural and cultural environments of Europe.

Its key objectives are:

- ☞ to improve awareness of geology as the foundation of modern European Landscapes
- ☞ examine the fragile and changing links between biodiversity and the geological landscapes that support it
- ☞ explore the interactions between historic cultural developments and geology
- ☞ and review approaches to managing landscape heritage.

These objectives will be examined in 8 thematic sessions, as well as by pre- and post-Conference excursions to selected regions in Northern Ireland and the Republic of Ireland.

The Conference is being organised by the Royal Irish Academy in association with the Geological Surveys of Ireland and Northern Ireland, and with the support of the Heritage Council of Ireland and ProGEO, the European Association for Conservation of the Geological Heritage.

A conference First Circular is now available, (included with this mailing) or by email as a .pdf attachment.

For further information contact: John Morris, GSI, email: johnmorris@gsi.ie

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Karst and Wildlife

On a recent visit to China one of the landscapes that intrigued me was the Karst landscape in the vicinity of Yangshuo. We arrived at night, and when looking out of the hotel bedroom window the next morning, we were surprised to see a small, impressive, conical-shaped hill on the other side of the road. This was in the province of Guangxi, which is in the southern part of the country. To get the overall picture, karstified limestones cover approximately one tenth of our land surface, but one quarter of the world's population lives in these regions. Some major karstified areas are southern China, large areas of central and southern Europe, and much of Central America.

Trying to find a connection between karst country and birds was very difficult. Magpie robins were plentiful, but then they turned up in other parts of the country. Well at least they were happy in the karst, a succession of small conical hills, which extended as far as the eye could see. Cycling along a quiet country road was much more pleasant than motoring along, with every turn of the road revealing yet another hill, and another, and another. Spotted doves were also to be found in the karst areas. They would usually be seen on the ground feeding, either singly or in small groups, and they would nest on bushes or the small trees that grow on the hillsides. Sulphur-breasted warblers and yellow-bellied tits, what wonderful names, lived on the sides of the hills. They might well have appreciated the steep hillsides, where it would be mostly impossible to climb. We climbed one of the more famous karst hills, but there was help in the way of man-made (and woman-made) steps, which enabled us to do the climb. It was still difficult, but without the steps it would have been well neigh impossible. It is worth going to China just to visit and admire the karst country.

Looking at karst country closer to home, I find that Antrim and Fermanagh have karstic peculiarities, not to mention the Burren of Clare. Karst is a condition caused by water dissolving on some rock types, giving strange shapes in the landscape, with underground water-induced shapes like caves and stalactites. In parts of China and the Philippines, symmetrical conical hills stretch as far as the eye can see. In Fermanagh, rain fell on rock over the centuries, permeated through the rock, and the acidic quality of the water made holes in the rock. These holes slowly grew, small rivulets formed which wore away more stone until rivers appeared. Over the passage of time the Marble Arch Caves formed, and these have turned into an internationally famous tourist/geographical attraction.

As to wildlife, I can not perceive any great difference in the Marble Arch area wildlife, and wildlife in the surrounding countryside. The original progenitor of the Irish Yew tree comes from nearby, but whether this has anything to do with karst is another matter. The longest cave in Ireland is in Clare in the Burren. This again is part of the karst system, but with caves instead of conical hills. Wildlife on the Burren, especially flowers and butterflies, is different from the rest of the country, and similarities can be seen between here and the Iberian Peninsula. Again, what is the karst link? In Antrim, the famous Fairy Lough of Loughnahimrine, subject of a famous poem, has its own karstic idiosyncratic peculiarities. Rivers flow into it, but apparently no rivers flow out, yet the level can go down and down. In this case as well, there are no conical hills, only hidden rivers. Again the wildlife is not any different from other spots in Antrim. There are golden plovers, and the possibility of Scottish raptors like white-tailed seas eagle and golden eagle. The last golden eagle to live in Ireland was in this vicinity.

If you fancy a lifetime of study on karst areas of the world, this is your chance. But I fear it would be a lifetime commitment! The first thing you could do is to acquire a new publication of ***The Karst of Ireland***, mostly dealing with indigenous karst, but there is some mention of other parts of the world (see article in this newsletter).

Pól Cormacain, Environmental Protection Agency

Conor MacDermot – An Appreciation

Most readers of the Newsletter may not have met or heard of Conor. Yet, while not a hydrogeologist, he has made a substantial contribution to progress in the groundwater area in Ireland. Unfortunately Conor died, aged 56, on 9th September after a short illness. Conor was primarily a bedrock (limestone) geologist in the GSI. However, his interests and knowledge encompassed many other areas: karst, databases, IT, communicating geology to non-geologists, photography, archaeology, genealogy, etc. It was these interests, together with his knowledge of limestones in every part of Ireland that made him a regular and valuable contributor to Groundwater Section work. He constantly advised us on bedrock geology, particularly on limestones, which are our major aquifers. We stretched his patience at times, but we learned when not to approach him! Even in hospital he gave me advice on the limestones of north Roscommon. In this way he has made a significant input to many of the groundwater protection schemes produced in the last 10 years. His background in limestone geology and his enquiring mind led him to an interest in karst; so much so that in the early '90s he set up, on his own time, a flood level monitoring system in the Gort-Kinvara area, and in the process produced crucial water level data for the numerical model produced as part of the OPW funded investigation of the flooding problems in the area. Although I was the 'official' GSI advisor to OPW on this project, Conor usually knew far more about the area than I did; a situation that was somewhat embarrassing for me at times, although Conor was usually kind! He was determined that the Karst Booklet should be on the GSI website and, with the help of John Dooley of GSI's Cartography Unit, made this happen. He insisted that the GSI Groundwater Newsletter should be on our website. He encouraged/enforced Groundwater Section to set up a computer well database in the late '80s, which now has details on over 25,000 wells, and he helped us link this to our digital map production system. He often attended and contributed to IAH Technical Discussion Meetings. In the last year, he advised us on the geology and karst of north Roscommon, and following a field visit produced a fascinating guide for the GSI web page on "Roscommon's hidden landscapes" at http://www.gsi.ie/staffhome/macdermc/index.html This will become the basis for the planned IAH (Irish Group) fieldtrip in 2002. Groundwater Sections, Geological Surveys and the public service need people like Conor; unfortunately he is irreplaceable. That is the somewhat selfish perspective. However, let there be no doubt, Conor, as a person, is a person we will really miss.

Donal Daly, Groundwater Section, GSI

CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

Contributions for the next issue should arrive before 1st December 2001 to:

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