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THE GSI GROUNDWATER NEWSLETTER

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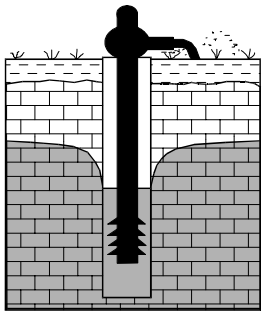

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Edited by: Donal Daly

No. 28 December 1995

IN THIS ISSUE

"Waste is something that everyone wants you to pick up but no one wants you to put down" was a wry comment made a few years ago by a local authority engineer who was having difficulty in finding a suitable landfill site. (The same engineer, on occasions in frustrated and unthinking moments, would blame GSI guidelines/recommendations for hindering him in 'putting the waste down'!!) Little has changed in recent years (apart from improved landfilling standards in some counties) – landfill site selection is perhaps even more difficult and contentious now. There can no longer be any question that **hydrogeological/groundwater factors are crucial in landfill site selection, design and management**. The proposed **EU Landfill Directive** (see page 11 for details) confirms this. There can be no doubt that **landfill leachate** has the **potential** to pose a significant **risk** to the environment, particularly to **groundwater** and **surface water**. How can this risk be handled? Some (although now fewer and fewer) would claim that engineering measures alone, such as artificial liners, will prevent problems. However, it is now clear that this view is inadequate and that the **risk** depends not only on **engineering control measures** but also on the **nature and aquifer potential of the underlying geological materials**. The sensible approach is therefore to combine low risk (or as low as practicable) geological and hydrogeological situations with liners (if required). How can such situations be located? The GSI recommends using **groundwater protection schemes**, either by way of having a scheme prepared or by using the general principles, backed up by desk studies and site investigations. The GSI also recommends that **landfill sites should not be located on regionally important (major) aquifers** unless the hydrogeological conditions preclude pollution of groundwater (situations that are uncommon and difficult to locate) or other exceptional circumstances apply. The basis for this recommendation is outlined on pages 2-5.

As part of the 150th anniversary celebrations, the GSI organised an **Environmental Geology Symposium** in October, at which speakers from six countries gave papers. The **abstracts and conclusions** of most of the papers are given on pages 6-15.

The **degree of solution and karstification of limestone** is poorly known for many parts of Ireland. Yet it has important implications for groundwater protection and development, mining and infrastructural development (due to subsidence, for instance). A **Working Group on Karst** (page 16) has been set up with the general aim of improving the situation.

High **iron in groundwater** is a frustrating and difficult problem in some areas. Suggestions on ways of avoiding and combating the problem are given on page18.

Editor

THE LOCATION OF LANDFILLS ON REGIONALLY IMPORTANT (MAJOR) AQUIFERS

INTRODUCTION

The selection of landfill sites is and will continue to be difficult and contentious. Since the early 1980s, the GSI has recommended that landfills should not normally be located on major (*regionally important*) aquifers (Daly and Wright, 1982). While this recommendation has received a good degree of acceptance, the planned publication in the near future of the EPA Landfill Manuals and difficulties with locating landfills in two local authority areas, have made this issue topical. As a means of explaining and clarifying the GSI view, I have set out i) the background factors that provide the basis for the recommendation, ii) the reasons for the recommendation, iii) a proposed site selection approach and iv) possible situations where landfills on *regionally important aquifers* could be defensible.

BACKGROUND FACTORS

Regionally Important (Major) Aquifers in Ireland

- The risk to groundwater posed by a landfill depends on the aquifer potential of the underlying rocks. In delineating aquifers for any area, the GSI uses three broad categories – *regionally important (major*), *locally important (minor)* and *poor* (Daly, 1995a).

- *Regionally important (major) aquifers* contain substantial groundwater resources which are available for use by the general public, farms, local authorities (for public water supply schemes), or industries, both now and in the future.

- It is EU policy that pollution of all usable groundwater must be prevented whether the resource is used or not. Consequently, the present degree of usage of a *regionally important aquifer* is <u>not</u> an issue when considering the location of potentially polluting activities, such as landfillls.

- About 30% of the country is underlain by *regionally important aquifers*. They include certain Carboniferous limestones and sandstones, certain volcanic rocks and Quaternary sands/gravels. Although the aquifer boundaries are not always clear-cut in some areas in Ireland, sufficient information is now available for many parts of the country to enable *regionally important aquifers* to be delineated with a good degree of confidence. Even if these areas cannot be delineated with certainty, site investigations can provide sufficient information to enable any site to be categorised using the GSI guidelines.

- The geology and hydrogeology of this country are complex. Firstly, the subsoils are variable in thickness, extent and lithology, reflecting their chaotic mode of deposition during the Ice Age. Secondly, the bedrock in Ireland has a fissure permeability only and frequently is variable in its hydrogeological characteristics, i.e. it is heterogeneous and anisotropic. These two factors make predictions of groundwater flow difficult and somewhat uncertain. The second factor means that relatively little attenuation occurs in bedrock and flow velocities are relatively high. (The situation in Britain and several other European countries is significantly different because a high proportion of the bedrock has an intergranular permeability only or a dual permeability - see articles in issue No. 27 of the GSI Groundwater Newsletter.)

- Groundwater in *regionally important aquifers* is, in general, more vulnerable in Ireland than in most other European countries.

- Groundwater flow paths in *poor aquifers* in Ireland are conceptualised as being relatively short, with discharge occurring nearby into drainage channels and streams. In *regionally important aquifers*, flow paths are usually far longer – hundreds of metres to several kilometres. Also flow velocities are usually higher in *regionally important aquifers* and high permeability zones are more likely.

Groundwater Protection

- Remediation of contaminated aquifers is always difficult and frequently impossible at an economic cost. Consequently, contamination prevention is essential.

- The GSI has proposed the usage of **groundwater protection schemes** as a means of preventing or minimising the risk of contamination (Daly 1995a).

- Groundwater has a very high priority in EU policies and Directives: the Groundwater Directive; the proposed Groundwater Action Plan; and the proposed Landfill Directive. Annex 1 of the proposed Landfill Directive deals to a significant degree with geology, hydrogeology and groundwater (arguably, to a greater degree than any other issue) – thus highlighting the critical role of these factors. Groundwater is one of the highest priority environmental issues for the EU.

- Principles such as the precautionary approach and sustainable development have been adopted as national and EU policies. The proposed groundwater protection scheme is a means of implementing these

principles and of undertaking several of the requirements of the proposed EU Groundwater Action Plan.

- Risk is an important concept in decision-making on the location of potentially polluting activities. (Risk is mentioned in EU directives, for instance.) Therefore, risk assessment and risk management are becoming important tools in planning. They provide the basis for the GSI groundwater protection scheme and for the GSI recommendations on landfill site selection.

- The minimisation of risk to groundwater and surface water from potentially polluting activities is a desirable objective of general land-use planning. The location of a major potentially polluting development above an important groundwater resource (or in the zone of contribution of a public supply well) represents an unnecessary risk in planning terms where such risks can be avoided. For instance, the concept of "avoidable risk" was an issue in the hearing on the Galmoy Planning Appeal.

Landfills

- Landfill leachate poses a significant risk to groundwater. In particular, there is sufficient evidence available to suggest that it should be assumed that leachate from municipal solid waste will contain List 1 substances; substances which are prohibited by the Groundwater Directive from discharge or release into groundwater.

- Even if landfills have liners installed in accordance with best engineering practices, it should be accepted that such liners leak (see Daly (1995b) for further information on this point). Two recent papers highlight this. According to Vallance and Savory (1995), "whether landfill sites are engineered with lining systems or not, they are expected to leak some leachate; total containment cannot be achieved". Buss et al. (1995) have considered diffusion of VOCs through synthetic liners. They suggest that "it is possible that diffusion may have a significantly greater potential for contamination than the leachate produced by hydraulic flow".

- The proposed Landfill Directive requires that pollution of groundwater must be prevented. The engineering measures that they describe do not guarantee pollution prevention.

REASONS FOR NOT ALLOWING LANDFILLS ON REGIONALLY IMPORTANT (MAJOR) AQUIFERS

- It is likely that even a "containment" landfill on a *regionally important aquifer* will contaminate the aquifer in the medium or long-term and perhaps even in the short-term. As landfill leachate is likely to contain List 1 substances, such contamination could be serious and in breach of national regulations and the EU Groundwater Directive .

- The location of a landfill on a *regionally important aquifer* will effectively preclude usage of the resource in the vicinity of the site for decades, particularly down-gradient of the site (for several kilometres, in some instances), thus inhibiting future development of industries, agribusiness, tourism, etc.

- Because of the often unpredictable and relatively high flow rates in *regionally important aquifers*, routine monitoring may not detect the contaminants. The situation in karst is particularly difficult. Also, remedial action is likely to be impracticable.

- As groundwater in *regionally important aquifers* contributes a large proportion of stream flow, groundwater contamination, particularly by persistent species, can endanger surface waters and their flora and fauna, as well as any human users.

- The location of local authority landfills on *regionally important aquifers* will make it difficult for the local authority to encourage and enforce the location of other potentially polluting developments in low risk rather than high risk areas. In particular, it will make it difficult for local authorities to adopt and use groundwater protection schemes as a means of preventing groundwater contamination and as part of good land-use planning.

- The degree of containment required by the proposed Landfill Directive does not guarantee, particularly in the medium and long-term, prevention of contamination of groundwater, if permeable rocks are present beneath the liners and the hydraulic gradient is downwards. The GSI advocates using the proposed groundwater protection scheme as a means of following the spirit of the Directive.

- Acceptance of the view that every site can be "engineered" to be leak-proof has the following implications:
  - it is contrary to most expert views in the literature;
  - it implies that landfills can be located virtually anywhere e.g. on karst limestones, or in the source protection areas of public supply wells;
  - it assumes that mistakes during the construction and operation of the landfill site will not occur;
  - it implies great faith in the long-term ability of liners to contain leachate. This faith does not have a scientific basis.

RECOMMENDED SITE SELECTION APPROACH

- The GSI recommends using the framework provided by the proposed groundwater protection scheme as a methodology for selecting landfills.

- The proposed scheme is based on the concepts of risk, risk assessment and risk management and it uses matrices (one of which is shown below) as a methodology for encompassing the hydrogeological and contaminant loading aspects of risk assessment to decide on the location of potentially polluting developments.

- The preferred locations for landfills, from a hydrogeological perspective, are in areas represented by the zones on the right hand side and towards the bottom of the matrix. The closer that a site is to the bottom right hand corner, the less the risk to groundwater (the arrows indicate the directions of decreasing risk). As part of this proposed groundwater protection scheme, the GSI recommends that landfills should not generally be allowable on *regionally important aquifers* (or in source protection areas for public supply wells). The advantages of this approach are as follows:

  - It allows the obviously unsuitable areas to be avoided - vulnerable limestone aquifers, most sand and gravel areas - and therefore avoids time-consuming and expensive assessments in these areas.
  - It allows the optimum and the generally lower risk areas to be delineated, thus enabling investigations to be concentrated on these areas.
  - It helps ensure that an avoidable risk is not taken.
  - It follows the precautionary approach and can be regarded as "sustainable".
  - It is in line with EU policies, as outlined in the proposed Groundwater Action Plan
  - It is <u>defensible</u> in public enquiries as it enables comparisons of different areas and shows that the local authority focused on generally suitable areas.
  - It can be linked readily to other factors such as distance from the waste source, conservation areas, etc., particularly by using GIS.
  - For local authorities that do not have a comprehensive groundwater protection scheme, an outline scheme, which is an adaptation of the comprehensive scheme, can be used. In this situation however, a greater amount of investigation will be necessary to assess the vulnerability and/or the relative value of particular aquifers.

- A landfill on a *poor aquifer* will generally have far less impact because:
  - the permeability beneath the site is usually low;
  - the resource potential is small – there is little groundwater to contaminate;
  - any contaminated groundwater is not likely to flow far – it will usually re-emerge nearby and thus the problem is easier to control;
  - a major resource is not made unusable for future generations.

- Every county has a variety of aquifers, including *regionally important*, *locally important* and *poor*. Thus every county has a choice – landfill sites <u>can usually</u> be located on rock types which are not *regionally important aquifers*, and the inherent risks of siting landfills on *regionally important aquifers* <u>can</u> be avoided.

Matrix of Groundwater Protection Zones

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

(from Daly, 1995a)

SITUATIONS WHERE LANDFILLS ON REGIONALLY IMPORTANT (MAJOR) AQUIFERS COULD BE DEFENSIBLE

- Where the hydraulic gradient (relative to the leachate level at the base of the landfill) is upwards

for a substantial proportion of each year (confined aquifer situation).

- Where a map showing a *regionally important aquifer* includes low permeability units which cannot be delineated using existing geological and hydrogeological information but which can be found by site investigations. Location of a landfill site on such a unit could be defended provided leakage to the permeable units is insignificant.

- Where it is shown that there is no other alternative site and where containment is engineered to a higher standard than that required in other areas (by the use of multiple liners, for instance) and a sophisticated monitoring system is installed.

- Coastal sites where groundwater is saline or would become saline if developed.

- Where the waste is classified as inert.

CONCLUSION

In view of:

- the risk posed to groundwater by landfill leachate;
- the high priority accorded to groundwater by the EU;
- the need for statutory authorities to adopt policies to protect groundwater and to set a good example;
- the need to ensure that avoidable risks are not taken;
- the need for local authorities to have a defensible site selection process;

the GSI recommends that the statutory authorities should avoid locating landfills on *regionally important aquifers* unless the hydrogeological conditions preclude pollution of groundwater or exceptional circumstances apply.

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Donal Daly, Geological Survey of Ireland.

GSI 150th ANNIVERSARY ENVIRONMENTAL GEOLOGY SYMPOSIUM "*THE ROLE OF GEOLOGY AND HYDROGEOLOGY IN ENVIRONMENTAL PROTECTION*", OCTOBER 5-6, 1995.

Extracts - mainly the abstracts and conclusions - from most of the papers are given below and in the following pages.

The Role of Quaternary Geology in Environmental Protection

Abstract

More than 90% of the land surface of Ireland is covered by Quaternary deposits. These are loose sediments deposited largely during the periods of Pleistocene glaciation. In addition to glacial deposits, peat, alluvium and coastal deposits account for most of the remaining Quaternary sediments. In addition to this legacy of sediments glaciation has left a characteristically glacial physical landscape.

The most important role of Quaternary geology in environmental protection relates to its position vis-à-vis groundwater. Not only do the Quaternary sediments provide important aquifers, they are the medium through which almost all aquifer recharge in Ireland passes. Thus an understanding of the nature and thickness of Quaternary sediments is crucial to groundwater protection.

Quaternary sediments also form a very important source of bulk minerals. All our sands and gravels and most of our clays are Quaternary in age. In addition almost all agricultural soils are formed on Quaternary deposits. Peat, an important source of fuel, is a Quaternary deposit and practically any major civil engineering project encounters significant Quaternary geology.

When these, often conflicting demands on our Quaternary geological heritage, are set in the context of a growing desire to conserve what is in essence a Quaternary landscape the need for, and the demands upon, Quaternary geology databases become apparent.

Discussion

One's view of one's own locality is, of its nature, subjective. The person born on the edge of the Bog of Allen will have been conditioned to see the bog as a fuel resource or as a symbol of poverty or both. They may have memories of days spent with relations and neighbours cutting, footing, stooking, clamping and drawing home turf. At times they will have worked as part of such a *meitheal*. Other times they will have worked on their own. Although such memories, when probed, turn out to be some of the most pleasant and happiest, the bog is taken for granted. Equally the picture-postcard house snuggling into a hollow in an esker ridge is simply a house on mercifully dry ground. This sort of taken-for-grantedness emphasises that these are intimate, and often critical aspects of the environment of that locality. Equally, the water well in the esker gravel is taken for granted. The vulnerability of the well to pollution due to the permeability of the gravel is often not as obvious.

To the outsider the bog may possess an abstract kind of beauty and the esker may in addition have historical connotations and be part of a typically Irish scenery, and a "dirty" farmyard adjacent to a well is a scandalous state of affairs. This is not necessarily a more objective view. It is frequently based on a romantic view of the country-side simply as a place of beauty and recreation.

The conflict in value placed on these aspects of the environment is a microcosm of the conflicting interests in various aspects of the environment. Although this may seem simplistic or obvious, the validity of each opposing perception is not always acknowledged when considering environmental protection. Nevertheless, the values are different and conflict often ensues. Decision makers, particularly at local authority level often have to choose between two or more perceptions or value systems. In order that wise decisions can be made and that such decision making may be defensible in a legal sense, as much objective data as is possible will be required. The Geological Survey of Ireland, as the national agency for geological sciences is the chief repository of such data. These data are used in the production of geological maps which are usually the most convenient medium of transmission of the data to clients.

Irish Quaternary deposits are very variable. This means that the way in which they impact on society is also variable. Some local authority areas will have extensive sand and gravel occurrence, while others may have none and still others will lie somewhere in between. In addition the distribution and quality of the sand and gravel within such areas is also variable. All of these factors are

important when assessing the environmental impact of particular usage and the need for protection. In almost all cases sand/gravel is not a suitable medium for waste disposal and in this regard decisions are relatively easily made. There is, however a potential for conflict with regard to desired use with respect to extraction, use as an aquifer, as building land or for conservation.

A Quaternary geological map will indicate the distribution of such deposits and perhaps it will also indicate the distribution of other deposits of lower permeability and of less commercial value as bulk minerals. Tills for example generally offer better protection to groundwater, provide good foundation conditions and have low bulk mineral value. It should be clear therefore that a good Quaternary geology map is a very useful, indeed an indispensable, aid to good planning.

William P. Warren, Geological Survey of Ireland

Use of Geological Data in Land-use Planning

Abstract
Proper land-use planning requires a sound and appropriately designed geological or earth-science information base to determine on a continuing basis what problems may result from the various land-use activities and which geological conditions may be favourable for a particular land-use activity.

The role of the geologist in the land-use planning process is to provide geological information and analysis before planning, design, and construction. The specific information that geologists can contribute varies from area to area and from project to project, but generally it may include the following : the physical and chemical properties of earth materials, slope stability, presence of active or possibly active faults and fracture systems, depth to bedrock, depth to the water table, groundwater flow characteristics and floodplain extent.

The growing mass of geological information should be presented in a concise and practical form which the planners and decision-makers can readily use without a need to learn about natural stations are chosen based on hydrogeological and infrastructural criteria.

To minimise costs, only existing observation wells are included in the network. The data are resources in detail. One of the means to present this information is a resource evaluation system resulting into a land suitability map. The basic process used in the system is developing a series of individual maps showing specific kinds of information and superimposing them to identify a degree of suitability for a particular land use. Super-imposing can be done manually, photographically, or by computer. During the last decade a computer model has been developed that combines spatial information (geographical co-ordinates) and resource characteristics - a geographical information system (GIS). The recent advances of computers have greatly enhanced the effectiveness of GIS for a wide variety of mapping, planning and management needs.

Alexander Zaporozec, Wisconsin Geological and Natural History Survey, Madison, Wisconsin 53705, USA

Groundwater Level Monitoring in Switzerland

Abstract
Groundwater provides more than 80% of Switzerland's water supply. Groundwater level data are essential for the management and protection of groundwater resources. The cantonal authorities have the responsibility for enforcing the Federal Law on Water Protection. In order to do so, they operate their own groundwater monitoring networks. The density, duration and technical specifications of these networks vary widely from canton to canton. The Federal Authorities carry out investigations relating to the water resources of the country as a whole. The Swiss National Hydrological and Geological Survey (of the Federal Office of the Environment, Forests and Landscapes) has operated a groundwater level monitoring network since 1976. The aim of this network is to provide uniform and readily accessible data so as to characterise the regime of representative aquifers and their long-term behaviour; it should also provide a link between the cantonal networks. The monitoring

usually collected with an analogue recorder, then digitised, processed and electronically stored. A synthesis of all existing federal network data has recently been carried out. By 1994, this network consisted of 48 stations.

Most of the aquifers that have been examined are composed of alluvial deposits and their groundwater levels are controlled by surface streams. However, due to the diverse geological and climatic conditions in Switzerland there is a wide variation in the regimes of the different aquifers.

Conclusions and Further Developments

Based on the analysis of the data from the federal network, the following conclusions may be drawn. When the recharge of an aquifer is controlled by the infiltration of a river draining a large catchment, the interannual fluctuations of the groundwater level are reduced. This situation occurs frequently in Switzerland. However, even in such a situation, care must be taken to avoid possible overexploitation. On the other hand, when the recharge depends largely on local hydrometeorological conditions, the interannual fluctuations can be considerable. Therefore, the knowledge of the specific regime of an aquifer is always of paramount importance for drinking water management.

During the observation period, fluctuations over several years have been observed (e.g. relatively low groundwater levels from 1989 to 1992, rising trend during the following years). However, even when some stations have been observed for more than 15 years, extrapolation of the data for estimating the long term trend would be unreliable. For this purpose, an observation period of several decades is necessary.

The federal network should be continuously upgraded, based on evaluation of the collected data. Based on the synthesis published recently, some stations of limited significance have already been closed. The setting up of additional stations should improve the overview of the groundwater level fluctuations in all regions of the country.

Digitized data acquisition and electronic data processing are being gradually developed by the cantons and the Federal Authorities. In the future, in order to take advantage of this evolution, the exchange of data between these different institutions should be developed.

Another important task of the Federal Authorities is to set up a federal network for the monitoring of the chemical, physical and biological characteristics of groundwater. The SNHGS is participating together with other units of the Federal Office of the Environment, Forests and Landscapes in the necessary planning for this work. The planning of such a network requires however, a close co-ordination with the different networks concerned with the observation of the environment, which are either in operation or in preparation.

Jean-Pierre Tripet and Paul Buttet, Swiss National Hydrological and Geological Survey

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The Danish Nationwide Groundwater Monitoring Programme - Strategy, Results and Future Aspects

Abstract

The Nationwide Monitoring Programme was developed in 1987 and implemented during 1988. The motivation for initiating the programme was in line with the general international concern associated with the needs for reducing the deterioration of the aquatic environment caused by nutrients (nitrate and phosphate) from farming and industrial activities. The Nationwide Groundwater Monitoring programme consists of 67 representatives monitoring sites evenly distributed all over the country, where samples from a total of 1100 well screens present a reliable picture of the regional distribution of the groundwater quality. Additionally, monitoring results from production wells for drinking water have increasingly been included during the past 3-4 years. Beside nitrate and phosphate, approximately 80 additional substances important to the drinking water quality as well as to the general condition of the aquatic environment are included in the monitoring programme. Applying numerical taxonomy (clustering) for processing the chemical date, the groundwater can be classified into six main types reflecting regional patterns in the spatial distribution of the quality of

the groundwater and indicating the significance of geology, flow routes, percolation time (age) and human impact. Having run the programme for some years, trends in the water quality can now be observed, reflecting the vulnerability of the groundwater environment, and forming the basis for future planning of the Danish drinking water resources, including protection strategies, land use restrictions, legislation, and reorganisation of the water supply structure.

Groundwater Protection and Exploitation

The nationwide groundwater monitoring programme has proven its value during the past years, not only to keep track of the nitrogen etc., as originally planned, but also to identify and confirm the increasing deterioration of the groundwater by pesticides and chlorinated solvents. Until just recently the groundwater in Denmark was regarded as generally well protected, but the alarming results from the monitoring programme changed the general opinion significantly, and groundwater was looked on as a vulnerable resource of limited size. Safeguarding clean drinking water became a significant political issue and groundwater problems were given high priority. An important milestone was the government proposal for the protection of drinking water including 10 action points, of which especially the proposal for delineating areas of significant drinking water interest and protection of catchment areas for groundwater abstraction (zonation) was a key element.

The monitoring programme is going to be revised at the end of 1997 and this seems obvious to move the focus from the ordinary chemical constituents to the microorganic pollutants for more intensified analyses. The increased utilization of the monitoring data for groundwater quality impact assessment using modelling techniques for analysing the major relations (contaminant load, geology, flow, water quality etc.) will form a very valuable contribution to the identification of the areas vulnerable to groundwater pollution. An extended and improved monitoring system as outlined above will thus form a vital instrument for supporting the discussions of zonation of areas of special drinking water interest and their need for specific protection.

Bjarne Madsen, Geological Survey of Denmark and Greenland

Groundwater Databases and Monitoring in Ireland

Abstract
In Ireland, as in many countries, our groundwater databanks are characterised by extreme patchiness. In any given area, good data exist for only a few wells or springs where intensive investigations have taken place, but alongside, there are many wells and springs for which few data are available, and probably many others which are essentially unrecorded. This situation has several causes, primarily the absence of any statutory notification or reporting of well drilling, the general lack of concern about groundwater resources (at least until recently), and the lack of resources put into groundwater studies.

In this situation, groundwater investigators must make the best of patchy data, resisting the temptations of dismissing poor data out of hand or extrapolating the good data too far.

In recent years the GSI Groundwater Section has made great efforts to improve its databases and to make the data available to Ireland's growing groundwater consultancy sector. In undertaking groundwater protection schemes in several counties, all available groundwater data have been painstakingly compiled and entered into the GSI's main relational database. These files are then used to plot various maps through AutoCAD. In the future we hope to move to a GIS system.

Another major initiative has been to computerise the GSI's records of groundwater level fluctuations in about 40 wells in seven counties. These provide a good, though discontinuous, picture of groundwater levels in Ireland over the past 25 years, besides providing valuable information about the nature of the aquifers and the groundwater regime.

Introduction

The Geological Survey is the main state agency in Ireland dealing with hydrogeological data. Our groundwater data have accumulated over a period of about thirty years and for the most part are contained in three principal databanks:

- Details of wells and pumping tests
- Chemical analyses of groundwater samples
- Groundwater level monitoring data

In addition, we have an extensive and growing collection of reports on hydrogeology and related topics.

As in many countries, our data are characterised by extreme patchiness. In any given area, good data exist for only a few wells or springs where intensive investigations have taken place, but alongside, there are many wells and springs for which few data are available, and probably many others which are essentially unrecorded. This situation has several causes, primarily the absence of any statutory reporting of well drilling, the general lack of concern about groundwater resources (at least until recently), and the lack of resources put into groundwater studies.

In this situation, groundwater investigators (who need answers in a relatively short time) must make the best of patchy data, resisting the temptations of, on the one hand, dismissing poor data as useless, and on the other, of extrapolating the good data too far.

In recent years the GSI Groundwater Section has made great efforts to improve its databanks and to make the data available to Ireland's growing groundwater consultancy sector. This paper outlines the data we have (with an emphasis on our groundwater level data), and how we are working to improve its quality and availability.

Geoffrey R. Wright, Geological Survey of Ireland

The Correlation of Geology with Indoor Radon

Abstract

Elevated indoor radon concentrations are known to occur widely in western Ireland. The region is one of undulating glaciated lowland underlain by limestone bedrock of Carboniferous age which has suffered partial or advanced karstification. Current EU supported research by Irish and German Scientists is aimed at a better understanding of the geological factors that control radon generation, migration and ingress to dwellings built on such karstified limestone substrates.

Initial findings support the view that rock permeability is a key factor influencing radon availability at surface, even in poorly uraniferous rock types such as limestone; karstified limestone can act as a very efficient radon conduit. Soil gas mapping of Rn and He shows that radon migratory routes in bedrock are controlled by zones of enhanced permeability of a secondary nature (e.g. fractures, major joint, faults etc.). Radon entry routes at specific dwellings are linked to a localised occurrence of structural pathways in underlying bedrock. some of which are amenable to detection by geophysical methods (e.g. ground probing radar).

When combined with geological data, soil gas mapping methodologies are capable of predicting those areas where elevated indoor radon concentrations might be expected to occur most frequently. Their contribution to radiological protection is their capacity to delineate radon hazard zones in advance of urban development, thereby, allowing local authorities to implement radon-resistant building codes at the outset.

Patrick J. O'Connor, Geological Survey of Ireland

Geological Aspects of Coastal Zone Management

Abstract

The geology of the landward side of coastal areas is reasonably well known, that of the seaward part less so. The dynamics of the coastal areas, including tides, currents and sediment movement are only understood in a very general way. Management and protection of the environment requires information. Otherwise well meaning steps can do more harm than good. We lack basic information on many aspects of the coastal ecology and on the links and dependencies between topics. Geology is in a unique position in that it defines the habitats of the flora and fauna, influences current and sediment movements, and is influenced by them. The geology of the seaward part of coastal areas includes solid and Quaternary geology, the dynamics of sediment movements, engineering aspects and on occasion the extraction of minerals.

Raymond Keary, Geological Survey of Ireland

The Role of Geology and Hydrogeology in Selecting Landfill Sites

Abstract

The disposal of domestic and industrial wastes in landfill sites has the potential to cause various adverse environmental effects, including groundwater and surface water pollution. Landfilling is likely to continue to be the principal means of solid waste disposal in Ireland in the foreseeable future. Consequently good selection, design and operation of landfills have become a major engineering and environmental issue.

The standards being set for landfills in Ireland is influenced by the proposed EU 'Council Directive on the Landfill of Waste'. In Annex 1 of the 16/6/1994 draft, which is titled 'General Requirements for all Classes of Landfills', the

critical role of geology, hydrogeology and groundwater in the location of landfills is clearly stated. The relevant sections are quoted below:

1. The location of a landfill must take into consideration requirements relating to:

(a) .....

(b) the existence of groundwater, coastal water or nature protection zone in the area;

(c) the geological and hydrogeological conditions in the area

(d) .....

(e) .....

2. The landfill can be authorised only if the characteristics of the site with respect to the abovementioned requirements, or the corrective measures to be taken, following an environmental impact assessment if required under Directive 85/337/EEC, indicate that the landfill does not pose a serious environmental risk.

The concept of groundwater pollution risk is used as a framework for this paper and is proposed as a framework for landfill site selection. The different elements of risk and risk management are considered in turn: i) the contaminant loading; ii) the natural vulnerability of the groundwater; iii) the value of the groundwater resource; and iv) the use of land-use planning controls and preventative measures. The paper emphasises the importance of geological and hydrogeological factors in risk assessment and in landfill site selection. Groundwater protection schemes are recommended as a means of locating landfills in low risk areas. The paper also argues against dependence on technological means alone, such as the use of liners. It advocates combining modern technology and engineering with the geological materials in order to reduce the risks to the environment.

Summary and Conclusions

1. Wastes in landfills produce a noxious leachate, which has the potential to cause significant pollution of water. In particular, leachate may contain hazardous List 1 substances.
2. The movement of contaminants away from landfills and the likelihood of contamination are influenced by the underlying rocks. Factors such as the type, permeability and thickness of subsoils, karstification of limestones and the depth to the water table dictate contaminant movement and attenuation, and groundwater vulnerability to contamination.
3. In general, a high clay content, low permeability and thick subsoil reduce contaminant movement underground, increase contaminant attenuation and reduce the groundwater vulnerability.
4. A proposed EU Landfill Directive requires that leachate must be contained on site.
5. Containment can be provided either (i) naturally where the underlying rocks have a sufficiently low permeability and an adequate thickness, (ii) artifically by using synthetic materials and/or bentonite (a natural imported clay), or (iii) a combination of both.
6. Dependence on artificial liners alone to contain leachate can create unnecessary risks to groundwater, the environment and humans.
7. It is recommended that landfills should be located in optimum areas geologically and hydrogeologically – areas with no major groundwater resources or sources and areas with thick clayey subsoils and low permeability bedrock. Liners will frequently be needed, in association with the natural geological materials, to reduce the risks to the environment and to comply with the proposed EU Directive.
8. Groundwater protection schemes provide a framework for locating landfill sites in low risk areas. They also provide regional geological and hydrogeological information which allows the obviously suitable and unsuitable areas to be delineated at an early stage of the site selection process.

Donal Daly, Geological Survey of Ireland

Groundwater Protection in England and Wales

Introduction

The National Rivers Authority (NRA) of England and Wales published their national groundwater protection policy in 1992. The British Geological Survey (BGS), acting as consultants to the NRA, provided the hydrogeological basis for this national policy. A brief summary of the approach adopted is given in this paper but for more detailed discussion reference should be made to the papers by Adams and Foster (1992) and Robins *et al* (1994).

The two major elements of any groundwater protection policy are that :

(a) it should strike a realistic balance between the protection of resources (aquifers as a whole) and sources (boreholes, wells and springs) used for public potable water supply; and

(b) it must address the control of both point and diffuse sources of pollution.

Thus a two element procedure for land-surface zoning has been adopted as the general framework within which the NRA's groundwater protection policy is mounted. The elements are as follows :

(i) division of the entire land surface on the basis of vulnerability of the underlying aquifers to pollution; and

(ii) areas related to the catchment of, and saturated zone flow times to, individual groundwater sources.

Conclusion

Figure 3 shows how the separate elements of vulnerability and source protection are combined to provide an effective groundwater protection policy. The zones are delineated in both components have been used by the NRA to construct acceptability matrices of potentially-polluting activity (NRA, 1992). Since implementation by the NRA the policy adopted has shown to be useful in achieving the aims of groundwater protection and is proving to be a significant input to land-use management planning.

It is interesting to note that while any groundwater protection policy is dependent upon public awareness of the issues involved in order to be effective, the experience of the NRA is that implementation of the policy itself promoting public understanding.

The NRA's approach to groundwater protection will be compared and contrasted in the seminar discussion with aspects of the approaches adopted by different countries.

Brian Adams, British Geological Survey

Principles of Protection of Groundwater Supply Sources

Abstract

Protection of groundwater supplies against contamination is one of the most important tasks of modern hydrogeology. Groundwater protection strategies and alternatives can be grouped into three major categories: natural protection, preventive actions, and corrective actions.

The physical environment may provide some degree of natural protection with regard of contaminants entering the subsurface. A number of methodologies are available for assessing the sensitivity of ground water to natural processes and human activities causing contamination, such as land-suitability analysis and vulnerability mapping. However, the cleansing ability of earth materials is not unlimited and has to be complemented by human protective measures. There are two basic approaches that can be used: preventing groundwater contamination from occurring, and handling contamination after it has occurred through various corrective actions and remedial techniques.

Preventive actions may include well standards, contaminant source controls, land-use zoning, and regulations and laws. One of the more effective preventive methods is the delineation of protective zones around water supply wells, which has been used in Europe for many years.

In the United States, the U.S. Environmental Protection Agency (EPA) established in 1987 a nationwide program to protect public groundwater supplies. Techniques recommended by the EPA for delineating a wellhead protection area (WHPA) range in complexity from an arbitrary fixed-radius circle around a well to numerical models to define the zone of contribution. A semi-analytical ground-water flow model was developed that can be used to delineate WHPAs. It consists of four independent modules that may be used to calculate capture zones for one or more pumping wells.

Alexander Zaporozec, Wisconsin Geological and Natural History Survey

Vulnerability Mapping and its Uses in Switzerland

Abstract

A new Federal water protection law came into effect in Switzerland during November 1992. Studies aimed at improving the protection of groundwater in karst areas are being carried out to assist in the enforcement of this new law. For example the criteria which have been used to delimit source protection zones in karst areas are often inadequate and as a result the protection zones may be ineffective. So as to improve the situation, the Federal Office of the Environment, Forests and Landscapes (FOEFL) in collaboration with the Swiss National Hydrological and Geological Survey is developing a new approach to the delineation of protection zones in karst regions. This approach is based on the vulnerability mapping of the catchment areas of sources. Vulnerability is here defined as the intrinsic geological and hydrogeological characteristics which determine the sensitivity of groundwater to contamination by human activities.

The EPIK method, developed by the University of Neuchatel, is based on a semi-quantitative evaluation and on the mapping of four factors: the epikarst (an intensively karstified and highly permeable near surface zone), the protective cover, infiltration conditions (diffuse or point) and the karstic network. Vulnerability classes are obtained by combining the values of these four factors. As a result of the careful definition of these classes, their limits coincide on the map with those of the different protection zones defined in the Swiss regulations. The EPIK method is being tested in a number of pilot areas. Depending on the results of these tests, the FOEFL will decide if this method should be recommended in the guidelines accompanying the new law.

Conclusions and Further Developments

The new approach for the delineation of groundwater protection zones in karst areas based on vulnerability mapping takes hydrogeological factors into account. With the help of the EPIK method, a better source protection is expected. The method is being tested in further pilot areas (Tabular Jura, Prealps). It should also be adjusted for fissured, non-karstic aquifers. After completion of these tests, the Federal Authorities will decide if the method should be recommended in the guidelines accompanying the new water protection law. A possible further development of vulnerability mapping could be the extension of the method to resource protection, for karstic and porous aquifers.

Groundwater pollution in karst regions is not inevitable. For a better protection of these resources, priority has to be given to prevention. Prevention measures are preferable to complex drinking water treatment plants. It is a duty of hydrogeologists to explain to the specialists concerned that a better protection of karst aquifers is not only a necessary objective, but also a feasible one. All hydrogeologists involved in the development of the EPIK method are convinced that this new approach can contribute to the achievement of this objective.

Jean-Pierre Tripet[1)], Nathalie Doerfliger[2)] and François Zwahlen [2)]
[1)] Swiss National Hydrological and Geological Survey
[2)] Hydrogeology Centre, University of Neuchâtel

Groundwater Problems and Protection Methods in Lithuania

Abstract

The most important hydrogeological problems in Lithuania are outlined and practical solutions are discussed. The main problems facing groundwater are: contamination of shallow groundwater by agriculture; pollution in the vicinity of former Soviet military bases; and the protection of groundwater in the karst region. The hydrogeological data collected and stored by the Geological Survey of Lithuania and other environmental organisations are utilised for local, regional and national land-use planning. Likewise these data are used in the design and in the implementation of groundwater protection clean-up measures.

Introduction

Lithuania depends entirely on groundwater for its drinking water supply. The climatic regime ensures a positive water balance and Lithuania has very ample water resources. The mean annual precipitation across the country ranges from 540 to 930 mm. Geological conditions are also favourable for groundwater storage : sedimentary deposits vary in thickness from several hundred metres to as much as 2300 m (Kilmas and Paukstys, 1993). Hydrogeological estimates suggest a groundwater safe yield for Lithuania of some 3.2 million m^3/day (Juodkazis, 1979). About 2.0 million m^3/day of this groundwater has been investigated in detail and prepared for use. However, at present only about half of that amount is actually being used.

The inhabitants of Lithuania have used groundwater springs and dug wells as sources of potable water since ancient times. Nowadays some 14,000 drilled wells draw water from about 20 aquifers. But uncontrolled groundwater abstraction and pollution from human activities during the last 50 years of "planned" environmental policy, when noisy slogans advocating nature protection were far removed from the reality on the ground, resulted in serious ecological degradation of the natural environment. In this regard the subsurface environment was no exception. The products of human activity (hazardous wastes, organic and inorganic pollutants, hydrocarbons and heavy metals) have migrated with recharging precipitation. These pollutants have not only reached the vulnerable shallow unconfined aquifers, but even some deep confined aquifers as well. Despite the current difficult economic climate the Geological Survey of Lithuania together with the other environmental organisations have begun to tackle the most important groundwater quality problems and introduce necessary protection measures.

The following regional groundwater quality problems and practical solutions are discussed in this paper:

- nonpoint pollution of shallow groundwater by agriculture;
- point pollution of groundwater around former Soviet military bases;
- groundwater protection of the karst region of northern Lithuania.

Bernardas Paukstys, Geological Survey of Lithuania

Clean Up of Contaminated Aquifers - A Well Preserved Illusion?

Abstract
During the past decades considerable resources have been spent on reducing the deterioration of the environment, trying to improve the quality of water, and maintaining sustainable development. This is especially the case for groundwater. Because of the problems created by the past waste disposal practices, we have placed excessive trust in our ability to clean up old contaminant plumes and restore high quality groundwater. In light of various unsuccessful projects implemented in Denmark as well as abroad, there is an obvious need for a critical review of the reliability and efficiency of the remediation techniques and their justification in relation to restoration of contaminated groundwater reservoirs. the paper examines some of the key problems associated with clean up techniques illustrated by an example from an abandoned chemical waste dump in Denmark. At this site, several years of pump and treat remediation of groundwater contaminated with chlorinated solvents has recently been abandoned due to inefficiency. Instead, the site has now been left to recover naturally, under supervised monitoring. As a consequence, the questionable benefits of pump and treat techniques strongly supports the strategy of preservation of clean groundwater with emphasis on long-term and preventive measures rather than short-term solutions based on clean-up technologies.

Clean Drinking Water in Future

Recognising the weakness of pump and treat methods as a tool for cleaning up contaminated groundwater, this should be reflected in the discussions of future planning on how the limited resources for safeguarding groundwater quality can be prioritised. However, the pump and treat method will still be one of the tools to be considered for implementation of protection strategies. It is therefore of great importance to further develop and adjust the techniques. It can especially be recommended to design any pumping system on the basis of very conservative considerations with regard to the flow conditions in the aquifers, as well as to the geochemical environment and the chemical characteristics of the solutes.

The immediate consequence of a more critical review of the pump and treat method would probably be that a number of groundwater contaminated sites cannot be cleaned up within manageable limits, either in relation to time or to economy. As a logical consequence it has so far to be generally accepted, that there will be areas where the groundwater is not clean. It will therefore be of great importance to identify and protect the areas of significant drinking water interest which in future are going to form the backbone of the Danish water supply.

The experience gained during recent years has fully substantiated that also in groundwater management prevention is preferable to cure. Therefore the resources spent on preserving measures including sustainable exploitation instead of provisional remediation and short-sighted technical clean up solutions. The possible alternatives of todays protection measures including changed land use practice, forestation, nature conservation, etc.

should be part of a future integrated planning of groundwater resources and to the widest possible extend be utilised for the protection of future water supplies.

Bjarne Madsen, Geological Survey of Denmark and Greenland

The Symposium i) highlighted the important role of geological and hydrogeological data and expertise in understanding and assessing the impacts of human activities on the environment, ii) provided an opportunity to learn from the situation in other European countries and the US, and iii) gave information on the geological and groundwater databases in Ireland. The Proceedings of the Symposium (150 pages) can be purchased from the Publications Sales Section, GSI, for £15 + £1 for postage.

Compiled by the Editor

HYDRO, GEOLOGY AND THE ISLE OF MAN

The title *Hydrogeology of the Isle of Man* initially seemed appropriate for an article in the Groundwater Newsletter, but posed considerable difficulty in composing an offering of more than two short sentences. After all, geologists are a rare breed here, and the "hydro" prefix does nothing to soothe the puzzled, furrowed brow of the enquirer upon receiving an answer to the innocent "And what do you do?". It might be safe to say that groundwater has not yet arrived on the Isle of Man.

The Island's public water supply consists entirely of surface water, distributed from a number of reservoirs around the Island. Although a hosepipe ban has been in place for four months, it would appear that the water shortage is due to the distribution problem, rather than an actual deficit of water. The Water Authority is in no way inclined to even consider groundwater as an option.

The last well survey on the Island was carried out in the early 1950's, and 25 boreholes are recorded. These range in depth form 0.6m to 13m, but are predominantly shallow, and appear to be exclusively drilled in overburden*. Recorded yields are in the order of 1000 gallons per week, although one well is reputed to have served twenty-six people in a sanatorium. However, in 1934, a mains supply was received, and the well, presumably has not been used since.

There are plans to use groundwater for cooling purposes, as part of a current building project, and pumping tests have been carried out to date. If the plans prove successful, it will not only be an achievement for the environmentalists, but it could herald a new era of recognition for groundwater.

Geologically, the Manx Group predominate. These comprise greywackes, slates, shales, siltstones and slump breccias and they form the central uplands of the Island. Three phases of deformation have occurred, increasing the possibility of significant permeabilities. Carboniferous limestone outcrops in the south, and the north of the Island is flat to undulating, the thick Pleistocene cover concealing Carboniferous and Permo-Triassic deposits at depth. These include extensive gravel deposits.

The groundwater potential of the Island is yet unproven, but waiting to be found.

*Borehole data supplied by the British Geological Survey.

Reference: Ford, Trevor D. The Isle of Man. Geologist's Association Guide No. 46

Suzanne O'Sullivan, Consulting Hydrogeologist.

WORKING GROUP ON KARST

Geological Survey of Ireland **Geotechnical Society of Ireland**

International Association of Hydrogeologists (IAH) - Irish Group

Irish Association for Economic Geology (IAEG)

Background

Carboniferous limestones underlie more than half of Ireland. Some areas, the Burren region for example, are known to be highly karstified with the karst groundwater systems being active at present. Other areas, those of very impure limestones for example, are presumed to be non-karstic, the aquifer being of the fractured/fissured type rather than dominated by solutionally enlarged conduits. However, over much of the country the extent and significance of karstification is not known in any detail.

It is increasingly apparent that more information is urgently required concerning karstification in Ireland because:

- increasing use is being made of groundwaters from limestone aquifers
- aquifer protection plans require reliable information on the topic
- geotechnical engineers require such data for many projects, e.g. road construction
- mining developments in recent years have involved discussion on and investigation of karstification in the proposed mining areas.

Working Group on Karst

In order to improve the situation the Geological Survey of Ireland (GSI) initiated the setting up of a Working Group involving the International Association of Hydrogeologists (IAH) - Irish Group, the Geotechnical Society of Ireland, the Irish Association for Economic Geology (IAEG) and the Survey. The first meeting of the Group was held in December 1994.

The objectives of the Working Group are as follows:

- To establish liaison and communication between the different disciplines - hydrogeology, physical geography, geotechnical engineering and exploration/mining geology.
- To improve knowledge on and understanding of karst and karst groundwater flow.
- To provide advice and assistance to a joint TCD/GSI investigation into the extent of karstification of Irish limestones. (Much of the data compilation will be carried out by a TCD postgraduate student funded by the GSI.)
- To define terms such as "karst", "karstification", etc. in the Irish context.
- To highlight future research issues.

The objectives of the Group will be achieved by means of a variety of outputs:

- A summary report on karstification and its relevance to Ireland;
- A guide to karst for non-specialists;
- Maps, reports and a computerised database of karst features from the TCD/GSI study;
- A bibliography on Irish karst;
- A seminar in 1997 or 1998.

Working Group Membership

IAH Representatives: David Ball (☎ 4530320), Kevin Cullen (☎ 2697082), Eugene Daly (☎ 2876319), David Drew (☎ 6081888) and Paul Johnston (☎ 6081372).
Geotechnical Society of Ireland Representatives: Sean Mason (☎ 2694077) and Bernard Murphy (☎ 2600020).
IAEG representative: Annraoi Milner(☎ 4933149).
GSI Representatives: Donal Daly (☎ 6041490) and Geoff Wright (☎ 6041488).
Co-opted Members: Morgan Burke (GSI/TCD) (☎ 6041487) and Philip Jutson (GSI) (☎ 6041469).

Progress To-date

- ♦ A computerised database, using Microsoft ACCESS, has been created by Philip Jutson in consultation with the Working Group members.
- ♦ A set of data compilation and entry sheets have been prepared for 9 karst indicators – swallow holes, springs, caves, dry valleys, karren, enclosed depressions, estavelles, turloughs, boreholes (cavities, etc.).
- ♦ Relevant data has been obtained from K.T. Cullen & Co. and B. Murphy & Associates, and has been entered in the database.
- ♦ All the karst features on the old 6 inch to 1 mile geology maps have been recorded.
- ♦ Fieldwork in 5 areas of varying degrees of karstification has been carried out by Morgan Burke, as a means of examining indices of karstification.
- ♦ Over 600 references on karst in Ireland have been recorded.

Immediate Plans

- Completion of the bibliographic database, linked to the karst database.
- Short presentations to relevant groups as a means of publicising the value of the databases and the need for assistance in providing data.
- Contacts with hydrogeological and geotechnical consultants, drillers, exploration companies, academics, local authorities etc., to obtain access to existing data and to request recording of evidence of limestone solution on the data compilation sheets.

A Request for Assistance

The output of the Working Group, in particular the databases, has the potential to significantly improve our understanding and knowledge of karst in Ireland and could contribute to construction, road building, mining/quarrying and groundwater abstraction developments, as well as groundwater protection. However, the success depends largely on obtaining sufficient information to make the databases and associated maps useful. Assistance from consultants, drillers, etc is essential. Consequently, if any Newsletter readers are willing to provide data or other assistance, please contact any member of the Working Group.

Donal Daly, Working Group Secretary.

UPCOMING CONFERENCE ON WEATHER AND AGRICULTURE

Irish agriculture accounts for almost 49% of net trade, i.e. exports minus imports. To ensure a vibrant future for this core industry, farm and agri-industrial practices over the entire food chain need to be constantly reviewed. Year-to-year variability of agricultural production is mainly due to weather. But new pressures have entered farming in recent years. In response to consumer preferences (e.g. food quality and food image) and EU regulations, farm practices must now more than ever be in harmony with the environment. Engineers, hydrologists, environmentalists and agricultural consultants have an increasingly important role to play in serving the agri-industry well. The interaction between weather and climate and the farm enterprise is now more than ever of central importance in farm management.

The AGMET Group is holding a 2-day Conference entitled **Climate, Weather and Environment – Key Factors in Irish Agriculture** in Johnstown Castle on Thursday February 29 and Friday March 1, 1996. Speakers include Avril Doyle, the Minister for State at the Department of An Taoiseach, and experts from Teagasc, Meteorological Service, Farmers' Journal, Universities and agri-consultancy. Talks will be concerned with the use of weather information in farm management; the interaction of climate, environment and agriculture; and weather and farming in the 'green' era. There will be associated social events and a visit to the environmentally interesting area of the Wexford North Slob. A Conference fee of £60 includes the proceedings; a copy of the Agmet Atlas which will be launched at the Conference by Brendan Howlin, Minister for the Environment; Conference dinner; lunches and coffees. The programme and full details may be obtained from Willie Murphy, Teagasc, Johnstown Castle, Wexford.

Tom Keane, Meteorological Service.

HIGH IRON LEVELS IN GROUNDWATER

Background

In recent months, the GSI have dealt with a number of requests for advice on the issue of high iron concentrations in public supply bored wells. Usually the iron problem has coincided with a gradual reduction in well yield. This article gives an outline of the advice given; advice that may be relevant to local authorities with similar problem wells.

Description of Problem

- "Rusty" water for up to 30 minutes after pumping starts.
- Drop off in yield, usually over a number of years (3 - 20).
- Deposition of iron oxide precipitate in reservoir.
- In one case, corrosion and perforation of the mild steel rising main.

Geology and Hydrogeology

- Old Red Sandstone and Namurian sandstones and shales were the rock types. (However, problems can also arise in muddy/impure limestones and Lower Palaeozoic and Precambrian rocks.)
- The aquifer category is usually "poor" or "locally important", so transmissivities and specific capacities are usually low.

Typical Hydrochemistry

- High iron (> 0.2 mg/l) on occasions.
- Relatively soft water in non-carbonate rocks (total hardness < 200 mg/l).
- Field pH usually < 7.0 in sandstones and shales.

Typical Well Design

- Mild steel liner, slotted below the water table.
- Larger diameter mild steel liner installed to rock head.
- Pump close to bottom of well.

Typical Pumping Regime

- Well is often pumped at relatively high rates for short periods (to meet peak demands), thus generating large drawdowns.

Possible Causes of Problems

1. Corrosion

- Corrosion of the rising main can be caused as a result of a galvanic cell between two metals in the rising main and pump, leading to enhanced corrosion of lower quality steel.
- Low pH and redox potential (Eh) can provide the potential for direct solution of steel

2. Reduction in Borehole Yield

- Due to the dry weather in 1995, the saturated aquifer thickness may have dropped, thus reducing the yield.
- Iron biofouling (iron slime caused by bacteria) or iron precipitation or a combination of both may be occurring in and around the slotted liner causing a reduction in the well efficiency.
- Iron precipitation and biofouling in rock fractures may occur due to the introduction of oxygen during pumping.

3. High Iron at Start of Pumping

- The wells were in rock types in which the groundwater has the potential to have high iron concentrations.
- Precipitation of iron at and above the water table during pumping; this iron is then available at the start of the next pumping period. This can occur when the well efficiency is low; either where the slotted liner does not have sufficient open area in the vicinity of the water bearing rock fractures to maintain low flow velocities, thus causing large drawdowns due to well loss, or alternatively in open holes where flow through fissures is turbulent and drawdown is large.
- Corrosion of the well liners and/or screen may be the source of the iron.
- A combination of corrosion and precipitation may be causing the high iron.

Recommendations and Conclusions

- Measure water levels regularly (monthly at least) before the start of pumping (the pump may need to be switched off overnight) and after pumping for several hours. The discharge should be recorded at the same time. These data allow an assessment of general variations in water level and an assessment of changes in the efficiency of the well.
- Measure dissolved iron and manganese, pH, Eh, temperature and electrical conductivity at the well head on flowing samples.
- In order to reduce and minimise biofouling and/or iron precipitation, the following operational practices are generally recommended:
  - operate boreholes for longer periods or continuously at an appropriate lower pumping rate;
  - where possible, ensure that pumping water levels do not fall below the top of the screen;

  - do not install the pump in the slotted liner/screen;
  - in general, reduce flow velocities in the well as much as practicable.
- A step test (where the discharge rate is increased in steps) to enable the well efficiency to be calculated should be carried out regularly (perhaps once a year where problems are suspected) to monitor well performance.
- If corrosion of the casing and screen is taking place, it is inevitable that a new borehole will be required, perhaps in 4-5 years. However, the borehole can still be used if the pumping rate is appropriate and constant.
- If iron biofouling and/or precipitation have reduced the well yield, the following options can be considered:
  - air surging and airlift pumping to dislodge the biofouling
  - chlorination to kill iron bacteria;
  - acidisation to remove precipitates;
  - drilling a new well.
- It may be necessary to drill a new well, or even two new wells, and in the process take account of the problems at the existing well.
- In order to increase the "life" of a new well, the following practices are recommended:
  - Before drilling, get the driller to disinfect the rig with a mild disinfectant and to wash it with hot steam, otherwise iron bacteria may be introduced at this stage.
  - Disinfect the well after drilling and every six months (approximately).
  - Use PVC or other corrosion resistant borehole casing, screen and rising main.
  - Maintain as low a drawdown in the well as practicable - for instance, pump for a longer period at a lower rate rather than a shorter period at a higher rate. Consider drilling two wells and pump both to reduce the drawdown.
  - Measure water levels regularly to monitor the well and to provide data in the event of problems arising.
  - Carry out borehole maintenance at appropriate intervals, possibly once a year.
- It is usually worthwhile employing an experienced hydrogeological consultant to provide advice on well location and design, and to supervise well construction.

Donal Daly[1], David Ball[2] and Jenny Deakin[3].
[1] GSI, [2] Consulting Hydrogeologist, [3] GSI/Limerick Co. Co.

IAH NEWS

IAH Technical Discussion Meetings

9th January **"Solutions '95". Report on the Edmonton Congress of IAH** (Technical Conference, Council Meeting and Burdon Commission) by David Ball, Consulting Hydrogeologist

6th February **A New Model to Interpret Glacial Sediments in Ireland** by W.P. Warren, Geological Survey of Ireland

Further details from Kevin Cullen ☎ 01-2697082 or Donal Daly ☎ 01-6041490.

Annual Groundwater Seminar

The annual seminar will be held in the Killeshin Hotel on Tuesday and Wednesday 23rd and 24th April 1996. The theme of the seminar is "***Water Wells : Drilling, Design, Performance, Maintenance, Protection and Rehabilitation".***

Further details are available from Donal Daly, IAH Seminar Secretary, c/o Geological Survey of Ireland.

NEWS FROM ABROAD

Britain: Curbs on Herbicide Usage

Regular contamination of drinking water supplies by isoproturon, which is applied to half of Britain's cereal acreage, has resulted in curbs by the Ministry of Agriculture, Fisheries and Food (MAFF). In some parts of Britain, isoproturon is now the most common cause of breaches of the EC limit of 0.1 µg/l by pesticides in drinking water. Until 1992, atrazine and simazine were responsible for most breaches; however they are now less common following a ban on their use in non-agricultural practices in that year. MAFF is applying a ceiling of 2.5 kg/ha for annual applications and have indicated that this may be cut to 1.5 kg/ha following research. Farmers will be advised on product labels not to apply isoproturon when soils are cracked to avoid rapid run-off into watercourses.

Source: The ENDS Report, No. 246, July 1995.

Is this an issue here in Ireland? Is isoproturon used in cereal growing areas like the Barrow valley? Are simazine and atrazine banned, as is the situation in Britain?

Britain: First Prosecution of a Petrol Retailer

Shell UK has become the first petrol retailer to be prosecuted by the National Rivers Authority (NRA) for causing groundwater pollution. Following a leak from a service station, benzene, toluene, ethyl benzene and xylene were found close to four boreholes sunk as part of the site investigation. The petrol additive MTBE was found in groundwater samples from two of the boreholes, and contaminants were found to be migrating towards the site boundary. The company was fined £2,500 and £904 costs.

Source: The ENDS Report, No. 247, August 1995.

Compiled by the Editor

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 three times each year.

Your contribution to the dialogue would be welcome. **Contributions should arrive before 20th February 1996** to:

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