Irish Groundwater Newsletter

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This, the 52nd issue of the Newsletter is marked by a change of editorship. Katie Tedd of GSI/TCD and David Drew formerly of TCD have replaced Jenny Deakin in the job. Many thanks to Jenny for doing such an excellent job as editor. Some modest changes have been made in structure and content. The title is now Irish Groundwater Newsletter and the logo (there since the first issue back in 1986) has been changed.

The contents are now subdivided into three sections (denoted by coloured tabs):

Articles Presenting the results of groundwater management and regulation in Ireland, as well as the results of ongoing or completed research projects. This section includes the inaugural Early Career Hydrogeologists' Network (ECHN) article, which the editors hope will continue in each subsequent issue.

New Research in Hydrogeology Summary reports on new or upcoming research projects from the institutions in Ireland which engage in hydrogeological research. These include the third level institutes, the Geological Survey of Ireland, the Environmental Protection Agency and Teagasc.

Hydrogeological News News of interest to hydrogeologists in Ireland; which includes short reports on the recent activities of the IAH Irish Chapter, as well as the IAH International. It also includes other groundwater related material such as new publications that may be of interest and where groundwater features in the media.

Feedback on the contents of this issue and more general comments on the changes in the newsletter are welcomed by the editors. Please contact the editors at groundwaternewsletter@gsi.ie.

Monica Lee, Groundwater Section, GSI
Katie Tedd and David Drew, Editors

In this Issue:

Cover photo: Knebel drilling rig [Nicola Salviani] **See page 32**

Amendments of the EU Groundwater Directive

Matthew Craig, Environmental Protection Agency

Details of the recent amendments to the EU groundwater Directive and implications for Ireland are explained. Potential confusion surrounding groundwater "standards" is clarified.

Background

2014 saw the first amendments to the EU Groundwater Directive, some eight years after the introduction of the Directive in 2006. The amendments are relatively minor and only relate to Annex II of the Directive i.e. the development and use of Threshold Values for groundwater. The rationale for limiting the changes to this Annex appears to be two-fold; namely that a) many countries expressed concern about wholesale change because the Directive was relatively new and still required time to bed in and b) following a review, in 2010, of the first WFD River Basin Management Plans, the Commission had concerns that the substances selected and associated Threshold Values developed by different countries varied considerably across Europe.

As there was no clear mechanism to identify why this variation existed, the Commission utilised the formal review process that was built into the Directive (Article 10) to initiate a review of Threshold Values; which would result in amendments being made to the text of Annex II. A few countries, notably Ireland and the UK, requested a review of Annex I of the Directive because of perceived differences in use of the prescribed groundwater quality standards for Nitrate and Pesticides. However, this was not supported by the Commission, who indicated that countries had the option to establish Threshold Values for these substances, as had been done in Ireland and the UK, and therefore the development of a common approach for these substances could be achieved via Annex II of the Directive.

Amendments to Annex II of Directive 2006/118/EC

The review of Annex II was overseen by the EU Working Group on Groundwater as part of its 2011-2013 work programme; resulting in Annex II being amended in three main areas, as follows:

- In Part A, the Commission aims to improve clarity on how countries can demonstrate the interrelationship between Threshold Values and the background concentration of naturally occurring substances;
- In Part B, the Commission has added Nitrites and Phosphorus (total) / Phosphates to the list of substances that countries may consider when establishing Threshold Values;
- In Part C, the Commission aims to garner knowledge on the rationale behind why countries have developed Threshold Values for particular substances, and how they apply the Threshold Values when classifying groundwater bodies. This information should be included in the River Basin Management Plans.

To assist countries the Commission have provided a series of indicative metrics in Part C that may be considered in their response e.g. the explanatory response could include information on a substance's intrinsic properties, its source and pollution extent. Other key responses relate to adaptation of receptor based standards, such

as Environmental Quality Standards for surface water, when establishing Threshold Values for groundwater classification.

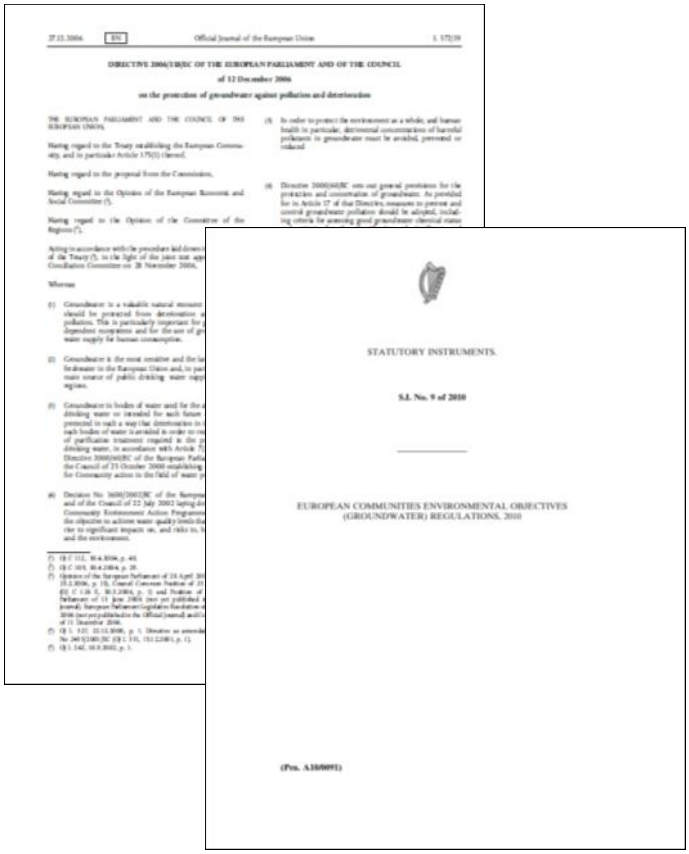
The Commission also requested that the EU Working Group on Groundwater undertake further comparison on Threshold Values across Europe and requested that the Working Group give further consideration to emerging pollutants as part of its next mandate.

Further information on the Groundwater Directive consultation and review process can be found on the Commission website.

Transposition of the Annex II amendments into Irish Legislation and implications for Ireland

Ireland has until June 2016 to transpose the amended Annex of the Directive into domestic legislation. This will require minor amendments to the Groundwater Regulations (S.I. 9 of 2010); primarily these changes relate to Schedule 6 of the Regulations.

Aside from the formal amendments to the text in the Regulations, the implications for Ireland are expected to be minimal because Ireland has already published Threshold Values for Phosphate and Nitrite in the Groundwater Regulations; has undertaken a study and developed Natural Background Values for a variety of key parameters (which will shortly be updated as part of an EPA STRIVE research project); and has published the associated rationale for the development and use of Threshold Values in an EPA report.


DIRECTIVE 2006/118/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 12 December 2006
on the protection of groundwater against pollution and deterioration

STATUTORY INSTRUMENTS.

S.I. No. 9 of 2010

EUROPEAN COMMUNITIES ENVIRONMENTAL OBJECTIVES (GROUNDWATER) REGULATIONS, 2010

The EU Groundwater Directive and the Irish Groundwater Regulations

Application of the Threshold Values identified in the Groundwater Regulations

The Groundwater Regulations have been in place since 2010 and provide the framework for regulating groundwater in Ireland. However, in Ireland the area of groundwater "standards" and their application causes a degree of confusion to practitioners and regulators alike. Primarily this is because comparisons are made between the Threshold Values and Environmental Quality Standards that exist in the Surface Water Regulations i.e. the Threshold Values are treated, by some, as being equivalent to Environmental Quality Standards. This is not how they were intended to be used, as the Threshold Values were primarily developed for the formal classification of Groundwater Status, which considered groundwater body scale impact. Therefore the Threshold Values were not intended for use as site specific, or compliance point, standards.

The Directive, and the Regulations, identifies three strands for groundwater assessment. The first, and arguably the most important, is the "prevent or limit" objective, whereby the input

of hazardous substances or non-hazardous pollutants is to be prevented or limited respectively. This is the most appropriate mechanism for site specific assessment and is the most relevant for establishing compliance values for the associated activities. A supporting objective relates to trend assessment, which can be used to demonstrate water quality improvement (receding plumes) at a site specific or regional scale. It's only when there is a failure of the "prevent or limit" or trend objective that the final status objective requires assessment i.e. for large, groundwater body scale pollution or definite impact on receptors.

It's possible to utilise the Threshold Values as a line of evidence in site specific assessments because they are designed to protect groundwater as a resource (or potential resource) and associated receptors that depend on groundwater. However it should be recognised that the Threshold Values are to be compared with annual average concentrations. Additionally, the list of substances with Threshold Values that are contained in Schedule 5 of the Groundwater Regulations only include those substances that were identified as being a potential driver for status failure in the 1st WFD Planning Cycle. Therefore they do not currently include many of the site specific substances that are causing localised pollution issues, in particular some of the hazardous substances that may exist in groundwater, but are not thought to be causing a groundwater body scale impact.

However, it should be pointed out that since 2009 considerable effort has been made in Ireland to characterise other substances that may potentially be causing groundwater body status failure and Threshold Values for these substances will form part of any update made to the Groundwater Regulations. Even with these amendments there is a need to establish "standards" for other substances that lack an equivalent regulatory value in Irish legislation. Establishment of a more comprehensive list of "standards" would address the *ad hoc* approach that currently applies, with compliance values derived from a variety of regulatory regimes across Europe and indeed the World. This in turn would result in a much more transparent regulatory system whereby the Threshold Values could easily be related to the "prevent or limit" standard and vice versa. As a consequence, this may help address concerns the Commission have with respect to the establishment and application of Threshold Values and may facilitate easier comparison of substances and standards across the different European countries.

References:

EU Groundwater Directive 2006/118/EC

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0118&from=EN

Amendments to Annex II of the Groundwater Directive 2006/118/EC

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0080&from=EN

EU review and consultation forum for Directive 2006/118/EC

http://ec.europa.eu/environment/water/water-framework/groundwater/review.htm

Methodology for Establishing Groundwater Threshold Values, the Assessment of Chemical and Quantitative Status for Groundwater and Groundwater Trends

http://www.epa.ie/pubs/reports/water/ground/groundwaterthresholdvaluesandassessmentofchemicalandquantitativestatus.html

Articles

Water Framework Directive Implementation and Integrated Catchment Management.

Where are we going? An EPA view.

Donal Daly, Marie Archbold and Jenny Deakin. Environmental Protection Agency

This article summarises the current situation regarding WFD implementation and catchment management. It is based on a paper by Daly, et al. (2014).

Progress To-date

Good progress was made in undertaking the 1st cycle river basin managements plans (RBMPs); an improved understanding of Ireland's water resources and the threats to it were gained and the reporting requirements of the Water Framework Directive (WFD) were met. In spite of the significant advances, some weaknesses were evident, particularly in terms of the programme of measures, and public engagement. During the recession, there was a hiatus in undertaking some of the key elements of the WFD and, as a consequence, the production of the 2nd cycle RBMP will be delayed.

New Governance Arrangement

New regulations – the European Union (Water Policy) Regulations 2014 (S.I. No. 350 of 2014) – and a consultation document on the timetable and work programme for the development of the 2nd cycle RBMPs have been published by DECLG (DECLG, 2014). These provide the direction for the future implementation of the WFD. They include details on new governance arrangements and the timetable for implementation of the WFD – in effect there will be a delay in the publication of the 2nd cycle RBMP(s) of two years, from December 2015 to December 2017. The revised governance structures are shown in Figure 1. As part of the

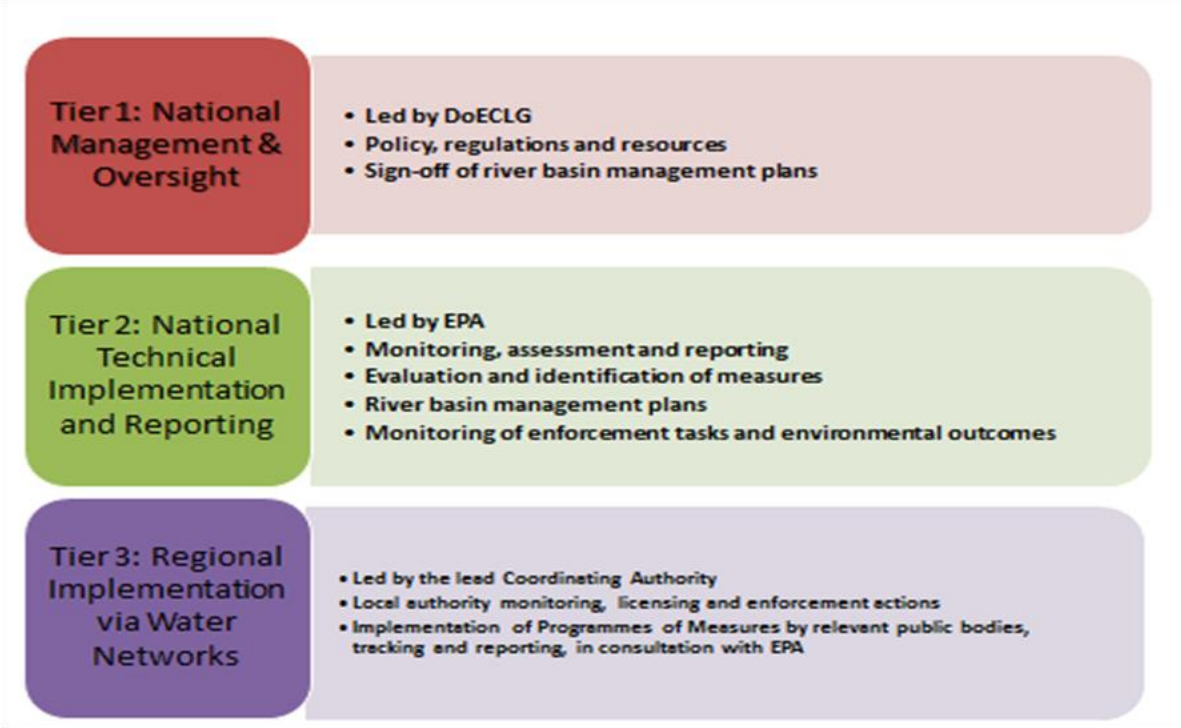


Figure 1: Proposed new governance arrangements

new arrangements, there will be a single national approach for the development of RBMP. It is planned to merge the existing seven RBDs into one national RBD, and one international RBD to be delivered in conjunction with Northern Ireland. In addition, technical analysis and planning will be undertaken on the basis of water or catchment management units, which will be decided on by the EPA.

As a component of the new arrangements, significant new responsibilities have been assigned to the EPA, together with additional resources. EPA now has a leadership role in technical implementation and reporting. The EPA will be :

i) undertaking catchment characterisation;
ii) reviewing the impact of human activities;
iii) preparing template river basin management plan(s);
iv) drafting environmental objectives; and
v) compiling common programmes of measures for further development and input by local authorities at Tier 3 and finalisation and approval by the Minister.

The local authorities, operating at Tier 3 will lead implementation and enforcement of the measures on the ground and have key responsibility for ensuring compliance with the Directive on public participation including consultation on draft river basin management plans.

A new section – the WFD Integration and Coordination Unit – has been established in the EPA to help facilitate the new EPA responsibilities. This Unit will undertake catchment characterisation (the foundation of catchment management), networking with internal colleagues and external stakeholders, and we will integrate existing work, knowledge and databases in a way that links all water types, pollutant pathways and pressures in a holistic manner.

Catchment Characterisation

Catchment characterisation is the foundation of water resources management as it provides an understanding of the physical, hydrochemical and ecological characteristics, impacts, sources of impacts and quantification of pollutant loads and abstraction pressures in the catchment.

Risk characterisation, which is a forward prediction towards the target deadlines and highlights the areas where monitoring and measures need to be implemented and/or adjusted so that the objectives can be met on time, has commenced. The first stage (Tier 1 characterisation) is a screening exercise, largely based on existing monitoring data and assisted by a newly developed automated WFD Application tool. This will be undertaken on water bodies (WBs), and includes an evaluation of current status, trend analysis, and evaluation of the environmental capacity of the water body by assessing the distance to a threshold, such as an EQS. The risk of groundwater bodies not meeting WFD objectives has been allocated into three categories: 'at risk', 'not at risk' and 'review', with 11% of all 578 water bodies 'at risk', 55% 'not at risk and 34% in the 'review' category.

All water bodies categorised have been aggregated into ~500 sub-catchments (sizes ranging from approximately 60-250 km^2). Tier 2 characterisation will be undertaken from mid 2015 to mid 2016 on these sub-catchments. The output of Tier 2 characterisation will be an analysis of the potentially significant pressures, the location of these pressures in the case of point sources and abstractions, the resilience of the ecosystems, and likely critical source areas in the case of diffuse pollution sources. Load apportionment work will help to determine which sources of nutrients are most important.

More detailed (Tier 3) characterisation will be undertaken in particular problem areas, potentially involving catchment walks, investigative monitoring, inspections and numerical modelling. The output of the Tier 3 characterisation will be an understanding of

which of the potentially significant pressures identified under the Tier 2 characterisation are actually significant, i.e. which are the ones that are actually causing the impact and therefore need mitigation measures. For example, the Tier 2 characterisation may highlight that diffuse sources of phosphorus are an issue within the sub-catchment, and the catchment characterisation tools will have identified the likely critical source areas. However, the catchment walks, investigative monitoring and inspections carried out as part of Tier 3 will be required to determine which likely critical source areas, or parts of critical source areas, or activities within those areas can be ruled out, and which should be brought forward for consideration at the next step for measures. Tier 3 characterisation will largely be carried out by the local authorities, with input from other public bodies and guidance from EPA. It will help provide a structure and a strategy for prioritisation for work essentially already being carried out.

The results of the WB and sub-catchment characterisation will then be used as the basis of catchment (Water Management Unit) characterisation, which will aggregate and integrate the information and conclusions from the analysis at the detailed scales to enable a holistic, regional assessment as a basis for evaluation of objectives, which may conflict in some circumstances, and the costing and prioritisation of mitigation measures. The proposed water management units (WMUs) are the catchments as defined, with some additions in the Shannon catchments, by the nationally-defined hydrometric units, giving 46 catchments/WMUs in the Republic of Ireland. They are shown in Figure 2.

Networking

The characterisation approach, and selection and successful implementation of measures and management strategies will involve integration of datasets and knowledge at a national scale. With this in mind, a Catchment Management Network has been established to provide a platform for the EPA, government departments and agencies, local authorities, other public bodies and environmental non-government organisations to work together to avoid duplication of effort while working towards RBMP delivery and achieving integrated catchment management. This Network will act as an umbrella for facilitating working groups on, for example, characterisation, measures, monitoring networks, hydromorphology and public participation. In addition it will identify where capacity building is most required in areas relating to integrated catchment management and provide/facilitate this training. The Network will also provide a mechanism for knowledge exchange and initiating public participation as the community involvement will be essential. Above all, it will enable catchment managers to come together to exchange ideas and assist one another in delivering the 2nd cycle RBMP and taking Ireland further along the path towards achieving integrated catchment management.

2nd Cycle River Basin Management Plan (RBMP)

As a precursor to completion of the 2nd cycle RBMP, potential mitigation measures will be identified and evaluated, management strategies will be reviewed and an implementation programme will be designed. The EPA will facilitate this process with the aid of the networking process outlined above, which will involve a broad range of public and private sector bodies and representatives. Economic analysis will be the responsibility of DECLG. The EPA will prepare a template RBMP; it is proposed that the Plan(s) will then be completed by local authorities, who will also be responsible for public consultation on the Plan(s).

In the next two years, the challenge to accomplish comprehensive and effective characterisation, and an implementation programme that will be capable of achieving

Figure 2: Proposed water management units (WMUs) (based on hydrometric areas)

successful catchment management for the benefit of Irish people is considerable. It will require hard work, realistic scientific analysis, judgements based on the available evidence, community engagement, and, above all, the cooperation of relevant agencies and individuals, both in the public and private sectors, including greater integration of work areas. And, it will need to be based, in our view, on the framework provided by the integrated catchment approach (ICM) approach (Daly, 2013). However, there is a momentum and ambition to achieve significant progress.

Beyond 2017

Clearly, while plans are necessary, they do not achieve catchment management. From late 2016 onwards, implementation will be the priority. Progress will need to be measured. The 3rd cycle of work will commence, building on the work of the 2nd cycle. As trends and outcomes are analysed, adjustments will need to be made. It is probable that the Tier 3 characterisation and community engagement will be key work areas.

While great progress has and is being made on the scientific aspects of catchment management, significant deficiencies in the areas of public participation and social learning need to be urgently addressed. Ó Cinnéide (2014), in an analysis on the evolution of the WFD in Ireland and Europe, concluded "If Europe is to achieve a tangible progress in reducing the environmental costs of diffuse water pollution, public participation and learning cannot be seen as an afterthought or as a discretionary, non-core element of the Water Framework landscape". He quotes Orr (2007), "We need to take a social learning approach in water, where we learn together how to make sense of complex problems and adapt our ways of managing". This area is, perhaps, our greatest future challenge.

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Articles

Irish Groundwater Protection: the next stage for the GSI

Monica Lee[1], Coran Kelly[2], Robbie Meehan[3], Caoimhe Hickey[1] and Taly Hunter Williams[1].
[1]Geological Survey of Ireland; [2]Tobin Consulting Engineers; and [3]Talamhireland Consultancy.

This paper charts the recent progress of the GSI's programme to provide Groundwater Protection Schemes and outlines the future areas of work that need to be addressed.

Introduction

Over the last number of decades, there has been increasing recognition and awareness of groundwater and groundwater protection, especially with the advent of the Water Framework Directive (WFD: 2000/60/EC; European Parliament and Council 2000). Groundwater is a significant natural resource that currently supplies an estimated 20-25% of drinking water in Ireland (EPA, 2011). It also provides significant contributions to wetlands and rivers, with an especially important role of maintaining flows through dry periods.

Groundwater in Ireland is protected under European Community and national legislation. The responsibility for enforcing the legislation resides with the Local Authorities and the Environmental Protection Agency (EPA). A vital element in groundwater protection is the use of relevant maps to make risk-based decisions. These maps and allied decision-making tools are provided in the Groundwater Protection Schemes (GWPS)[1]. A national GWPS, including a national groundwater vulnerability map, was completed for Ireland, by the Geological Survey of Ireland, in 2014. However, data gaps, the results of recent research, the future direction of WFD measures as driven by the EPA, and the increasing need for higher resolution three-dimensional (3D) information all highlight that groundwater maps and conceptual understanding needs to be improved.

Present: Status and Usage

The GWPSs, including their component layers (aquifer, groundwater vulnerability and subsoil permeability maps), are freely available for use by organisations, researchers and individuals. Their utility has been demonstrated by their inclusion in both national assessments and site-specific work. All Local Authorities are directed to use their GWPS in County Development Plans (Circular letter SP 5/03; DELG, 2003). The groundwater vulnerability map is used for source protection work throughout the country as well as a national data layer e.g. EPA risk ranking exercise for the National Inspection Plan for Domestic Wastewater Treatment Systems (2013). They are also available for the next phase of WFD work: proxy layers were used where GWPS maps were previously unavailable.

Development of Groundwater Protection Schemes

GWPSs in Ireland have been developing ever since their inception in the mid-1980s[2]. They focus on Irish water quality issues and potential sources of contamination, whilst being robust enough to adapt to emerging issues. The Groundwater Protection Schemes booklet,

[1]GWPSs provide guidance for specific activities based on the contamination risk they pose to groundwater (landfills, licensed landspreading, domestic wastewater treatment systems, earth-lined slurry stores, out-wintering pads, integrated constructed wetlands and, more recently, roads). They are also used for general guidance.

[2] The GWPS framework is based on a number of applicable, international methods used in countries with similar hydrogeology, whilst incorporating the results of Irish research (Fitzsimons et al., 2003; Lee, 1999; O Suilleabhain, 2000; Swartz, 1999; Wright, 2000).

Figure 1. Images from Field Mapping

which outlined the methodology, was launched in 1999 (DELG/EPA/GSI, 1999).

GWPSs were initially produced as county products, funded by the GSI and respective Local Authorities. During the 2000s, the GSI continued to produce county GWPSs but also focused its attention on the needs of the WFD: namely the provision of national datasets for groundwater body characterisation and risk assessments. The national aquifer map was completed in 2004 and the national groundwater vulnerability map 2013.

Completing the vulnerability map within the allocated timeframe required a regimented annual routine of: data collection; 6-7 months of fieldwork to gather subsoil permeability and depth to bedrock data (see Figure 1), which included a GSI drilling programme; data interpretation and map compilation; continual GIS and technical input.

Due to the progress over the 5 years (Figure 2a), the programme was extended to re-map additional areas/counties that were now considered to be out-of-date (Figure 2b).

Future: "Groundwater 3D"

In order to expedite the national GWPS map, some source protection work[3] and certain elements of the vulnerability mapping were postponed e.g. labour-intensive and expensive countrywide karst feature mapping. Furthermore, during this period a number of relevant pieces of research and geological mapping have been completed, which could improve existing datasets (e.g. the aquifer map), or could provide additional data to layer on the GWPS maps to improve the 3D conceptualisation of the subsurface. Additionally, our stakeholders are now requiring higher resolution information for specific management needs at catchment and sub-catchment scale.

To address these gaps and developments, the GSI is initiating/planning investigations into:

[3] Source protection mapping continued for the national groundwater monitoring programme (EPA) as well as for many group water schemes (GSI & NFGWS, 2013 - 2018).

Figure 2a. Areas in Each Mapping Year

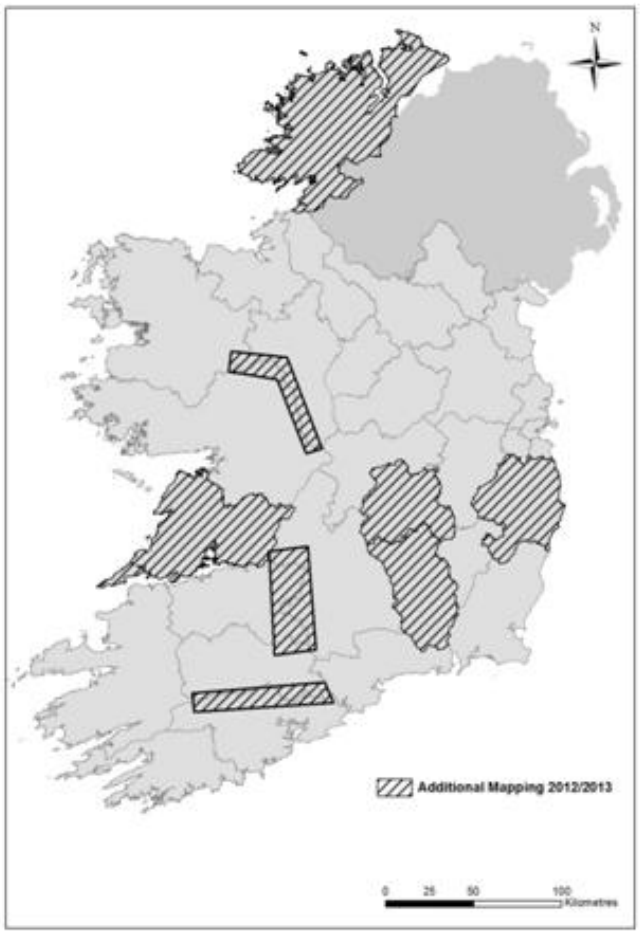

Figure 2b. Additional Mapping Areas

1) Karst: a) persistent drinking water quality issues in the highly karstified midland region (i.e. comprehensive dye tracer investigations); b) how karst features can be more efficiently mapped using remote sensed imagery (e.g. LiDAR).

2) Geologically complex regions where traditional investigation techniques have proved inconclusive. The initial focus is the North Cork area, where the majority of the drinking water is supplied by groundwater (over 30,000 m^3/d): a number of large karst springs supply a significant proportion of that water. However, repeated tracer tests have not provided any additional information. This area is now the focus of a Trinity College Dublin/GSI/ Irish Research Council pilot project that is testing out a new 3D modelling technique, KARSYS, developed by the Swiss Institute of Speleology and Karst Studies (SISKA), which has already been used successfully in Switzerland, Slovenia and Spain.

3) Improved contaminant pathway maps: building on the groundwater vulnerability concept and the outcomes from recent research (in particular the STRIVE funded PATHWAYS project). Investigations will look at the possibility of mapping of important sub-catchment scale contaminant pathways such as the transition zone and higher permeability layers within the subsoil.

4) Improved aquifer maps: a) incorporating the outcomes of recent bedrock aquifer research, such as the assessment of fracture systems on flow pathways work in UCD (J.P. Moore – current PhD project) and b) further site investigations into the mapped, and potential sand and gravel aquifers. An investigation of sand and gravel is likely to identify bodies that

may not be productive enough to be considered as an aquifer but may function as preferential flow pathways for contaminants.

5) National hydrochemistry: looking at national datasets to identify what information can be easily disseminated and where data gaps are arising.

In 2015, Geoscience Initiative (DCENR) funding was allocated to this process for an initial four year term to appoint a team of eight hydrogeologists and geoscientists to this task. The GSI is also utilising research funding programmes (e.g. the Irish Research Council's Enterprise Partnership Programme), working with international partners (SISKA), and is conscious of other programmes that have complimentary aims, both internally and externally, such as iCRAG.

The data collection, mapping and modelling programme for the next four years is based on stakeholder needs, but is also flexible enough to develop in certain directions if required. By the end of the four year term, the GSI will have improved the national maps and conceptual models, and will be able to provide considerably more information on groundwater systems in priority areas. The programme will allow data to be collected, collated and analysed with the ultimate aim of creating 3D models that can add so much to the understanding and management of the subsurface.

Acknowledgements

There are a number of individuals who have contributed to the development of the GWPSs over the years. We would like to acknowledge specifically the considerable contribution from Donal Daly (EPA, formerly GSI) for his development of the GWPSs programme. There has also been input from Geoff Wright, Vincent Fitzsimons, Jenny Deakin and Melissa Swartz (all formerly GSI), as well as Bruce Misstear, Paul Johnston and Eric Farrell (Trinity College Dublin). This paper is published with permission from the Director of the Geological Survey of Ireland.

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Articles

National Inspection Plan for Domestic Wastewater Treatment Systems: The first year's review of inspections

Margaret Keegan, Environmental Protection Agency

Approximately half of the almost 1000 septic tanks inspected by local authority staff to date have failed the inspection. The most common reason for failure is lack of de-sludging.

The Environmental Protection Agency (EPA) recently published its review of the implementation of National Inspection Plan: Domestic Wastewater Treatment Systems 2013 (EPA, 2013). The Plan is being implemented by Local Authorities under the supervision of the EPA.

The main findings were that:

- 90% of septic tank owners have registered their septic tank, this is very positive.
- 987 inspections were carried out by local authority inspectors.
- 52 per cent of domestic waste water treatment systems passed inspection.
- More than half the failures were due to lack of de-sludging.
- 79 per cent of the inspected systems are now compliant with the regulations, following remediation work by householders. This number is increasing all the time as work is completed.
- Advice to assist householders in maintaining their domestic waste water treatment systems is available through Local Authority leaflets and websites. Extensive information for homeowners is also available on www.epa.ie.

Domestic waste water contains human waste products and the discharge from the septic tank or treatment system may contain disease-causing bacteria, viruses and/or parasites arising from the population using the system. The chief recognised illness associated with exposure to inadequately treated domestic waste water is acute gastrointestinal illness causing fever, nausea and diarrhoea. Most cases are of short duration, but vulnerable people such as infants, pregnant women, the elderly or those with pre-existing health conditions are particularly at risk of serious health consequences if exposed to these pathogens.

Microbial pathogens arising from a septic tank or treatment system pose a threat in three circumstances:

Examples of poorly sited or poorly maintained Domestic Wastewater Treatment Systems.

- Where percolation into the ground is inadequate and ponding and/or direct discharge to ditches and streams occurs, with the potential for direct contact with pathogens by, in particular, children and domestic animals.
- Where the percolation area (or soak pit) is in the zone of contribution of a water supply well or spring and there is inadequate treatment of the effluent in the subsoil and/or bedrock, resulting in pathogens reaching the drinking water source.
- Where the site is suitable for a septic tank or treatment system but the system has not been designed and/or installed and/or maintained properly.

The inspections have, for the first time, allowed for the systematic collection of information on the condition of domestic waste water treatment systems in Ireland. The results show that many of the failures could have been prevented.

Through inspection of septic tanks nationally, it has been found that 48% of those inspected failed the inspection. The most common reason for failure was lack of de-sludging, which is the main maintenance issue for septic tanks. There is a grant available with conditions for some works if a system fails the inspection but this does not cover any maintenance issues like de-sludging.

In rural Ireland, many sites with septic tanks also have private wells, the inspection data shows that 52 % of sites with private wells failed the inspection, this is of concern. Data on the number of wells in Ireland contaminated by septic tanks is not available but it is estimated that 30% of groundwater wells are contaminated at some stage by E.coli, which may come from agricultural sources or septic tanks.

The findings of a study into 'before and after' attitudes among members of the public indicates that the high level of awareness of registration and inspections has not translated into a greater level of awareness of the need to, and the knowledge of how to, operate and maintain systems. There is a volume of information available on this subject, for example on the EPA website (http://www.epa.ie/water/wastewater/info/), yet this information is not being sought out by homeowners.

There also seems to be a number of misconceptions about the need to maintain wastewater treatment systems.

'I've never emptied it in 30 years, why should I do it now?'

'The sludge will break down better if I put a dead chicken/cat into it.'

I've no problem with it so why do I need to do anything with it?'

New regulations (S.I. No 223 of 2012) governing the operation and maintenance for domestic wastewater treatment systems (DWWTSs) require owners of DWWTS to operate and maintain their systems and this includes de-sludging. All domestic wastewater treatment systems require ongoing maintenance to ensure that the septic tank/treatment plant operates effectively and that solids do not enter the percolation area and clog the distribution pipe work.

The second National Inspection Plan for Domestic Waste Water Treatment Systems 2015 -2017 covering the period to the end of December 2017 will be published shortly, following a public consultation process. The Plan will not be revised in 2017 unless significant new information becomes available in the intervening period, which warrants a revision to the Plan.

The aim of the Plan is to protect water and human health from the risks posed by domestic

waste water treatment systems (DWWTS) by using a two-strand approach of engagement strategies linked with a risk-based inspection process.

Work carried out as part of Water Framework Directive (WFD) characterisation process and on-going EPA research projects will further determine the relative risk posed by domestic wastewater treatment systems.

Further information is available on the EPA website:

http://www.epa.ie/water/wastewater/info/

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Maintain your septic tank or packaged treatment system

You should have your septic tank or individual wastewater treatment system inspected and de-sludged (where necessary) at least once a year.

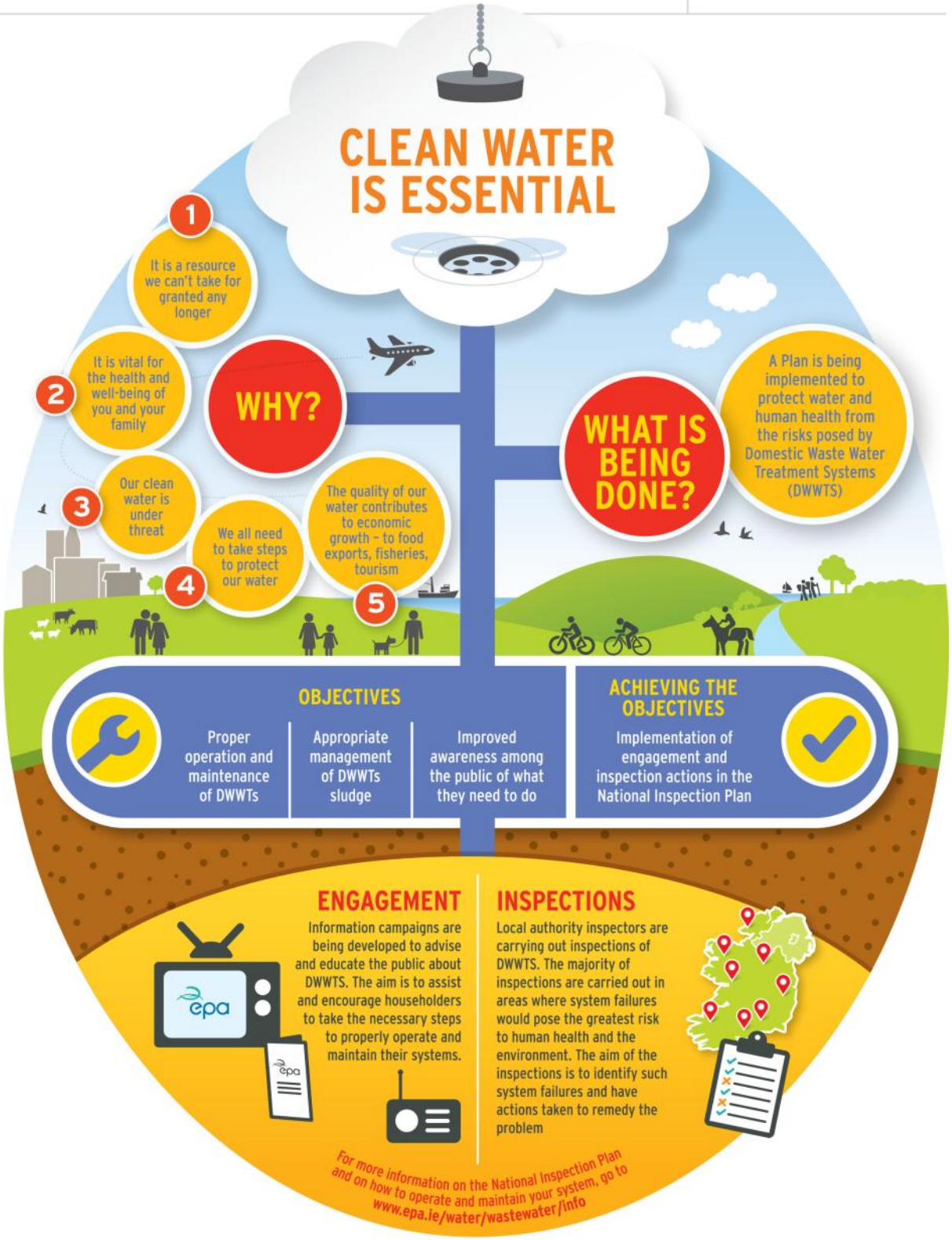
- If you never have to empty your septic tank/system it may be because it is leaking and the effluent is not being properly treated before it comes in contact with groundwater. This could result in contamination of nearby drinking water wells and may result in problems for you or your neighbours.
- If the tank is required to be emptied more frequently, then either it is sized too small for the number of people in the house or there is an inflow of groundwater into the tank.
- Either way the tank should be water-tight.
- If the level of sludge builds up in the tank it may make its way out of the tank and block the distribution box and the percolation area or polishing filter. And if the percolation area or polishing filter becomes blocked it is very difficult to clean and may require replacement – an expensive option!
- For secondary treatment systems an on-going maintenance agreement should be made and renewed with an appropriately qualified person to ensure that your wastewater treatment system is working effectively at all times.

Only permitted waste contractors should be used to remove the sludge – a list is available from your local authority.

Individual landowners can dispose of sludges from their own DWWT system by land spreading, strictly in accordance with the requirements of the Waste Management (Use of Sewage Sludge in Agriculture) Regulation, S.I. No. 148/1998, as amended.

Safety Note – it is dangerous to enter a septic tank or wastewater treatment system as they emit dangerous gases and only certified personnel should carry out this work.

NATIONAL INSPECTION PLAN FOR DOMESTIC WASTE WATER TREATMENT SYSTEMS



Articles

Preliminary Source Protection for Group Water Schemes: 2015 Update

Monica Lee and Shane Carey
Geological Survey of Ireland

An update on the Geological Survey of Ireland's collaboration with the National Federation of Group Water Schemes to provide preliminary source protection for Group Water Schemes.

In 2013, the Groundwater Section in the Geological Survey of Ireland (GSI), in collaboration with the National Federation of Group Water Schemes (NFGWS), embarked on a 5 year programme to provide preliminary source protection plans to Group Water Schemes (GWS). This followed on from a two-phase pilot project undertaken in 2011 and 2012.

The aim of the project was to enable the GWSs to more effectively understand and, therefore, manage their own drinking water i.e. go beyond providing useable information to effectively communicate any hydrogeological information, which would really enable GWSs to make defensible management decisions and take ownership of their drinking water supplies.

Approximately 540 GWSs are large enough (more than 50 people, or 15 domestic connections) to come under the terms of the Drinking Water Regulations (2007). Of these, just under 70% (c. 370 schemes) depend on, either wholly or in part, groundwater sources, whilst a proportion of surface water supplies are spring-fed. Approximately 250 of these GWSs[1] have been earmarked for this project.

Outputs

GSI suggested that GWSs would get the most value for money from a predominantly desk-based study delineating Zones of Contribution (ZOCs), which could then be combined with the existing national groundwater vulnerability maps. By doing this, GWSs would have a very good indication of where their water was coming from and, within that delineated catchment area, indicate where the risks of groundwater contamination were likely to be. This information could then be used to reduce the risk of future contamination or identify the most likely potential sources of existing contamination.

The GWSs receive a short, relatively non-technical report that lists the available information and outlines the 'sky to source' conceptual model of how rainfall reaches their supply. The report outlines the justifications for the ZOC delineation, includes a suite of maps and, crucially, makes recommendations for that GWS, that may include monitoring of the supply (quality and quantity where warranted), works aimed at improving the water quality (e.g. well head protection improvements, treatment options), potential land management options with the ZOC, and further investigations to improve the conceptual understanding if large data gaps exist.

To ensure effective transfer of knowledge, an intrinsic part of the programme is to fully engage with the GWS personnel at all possible stages of the project.

Progress to Date

Figure 1 shows the progress to date: 44 in 2013; 57 in 2014 and 50 underway/planned for 2015. The majority of the 2013 and 2014 draft reports were completed within the timeframe, although there is a risk of a cumulative delays occurring, principally due to the challenges of managing

[1]The final number of predominantly groundwater supplied GWS (with greater than 50 people, or 15 domestic connections) has not been fully determined. It is currently assumed to be around 250 GWSs.

such a large throughout of GWS studies (up to 50 per year) and number of consultants (up to 10). However, despite this, the continual work and patience of the consultants and input of the GSI and NFGWS has resulted in the completion of the reports, dissemination of information and increased engagement with the GWSs. This is of paramount importance as, ultimately, it is the individuals within the GWSs who live and work in their ZOCs that can potentially change their practices to make a difference to their drinking water.

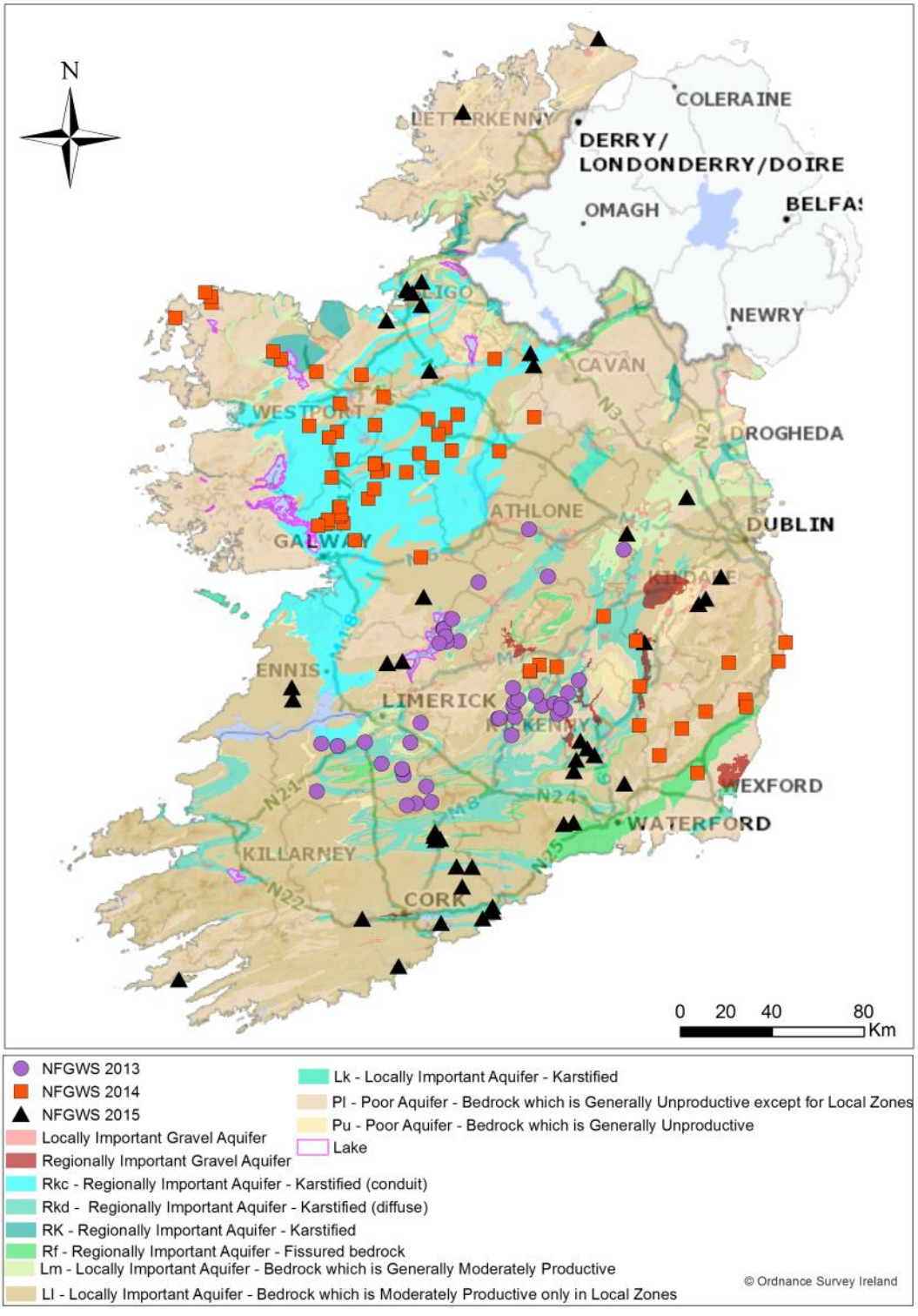


Figure 1. Progress to date with source protection for group water schemes.

Articles

Tellus: Bringing regional airborne geophysics and geochemistry surveying nationwide

Mairéad Glennon, Vincent Gallagher, Kate Knights and Ray Scanlon
Geological Survey of Ireland

An update on Tellus' activities, including examples of research using Tellus' data to explore groundwater related issues.

In summer 2012, the Tellus team reported to the Groundwater Newsletter on the progress of the Tellus Border project which was underway in the border region of Ireland, surveying for geoscientific data using airborne geophysics and ground-based geochemical sampling techniques. Three years on, the EU INTERREG IVA-funded Tellus Border project has successfully finished and surveying has moved southwards to the midlands region. The Tellus team intends to extend the baseline data collection and associated benefits nationwide and will shortly announce plans for the next survey phase.

Tellus surveying provides regional-scale data that inform management and decision-making on our environment and natural resources. As well as publishing multi-element geochemical data for three environmental media (soil, stream water and stream sediment) and three airborne geophysical datasets (magnetics, electromagnetics and radiometrics), Tellus facilitates value-added research on the data. Several research projects so far have used the Tellus Border data to explore groundwater-related issues. However the full potential of the datasets to support the assessment and management of the water environment has yet to be fully exploited and researchers and practitioners are invited to explore the data freely available at www.tellus.ie.

Based on the idea that variations in groundwater chemistry influence the conductivity properties of the subsurface, the

Figure 2 The airborne survey aircraft used for the Tellus Border geophysical survey, operated by Sander Geophysics Ltd of Ottawa, Canada, flying over Co. Fermanagh.

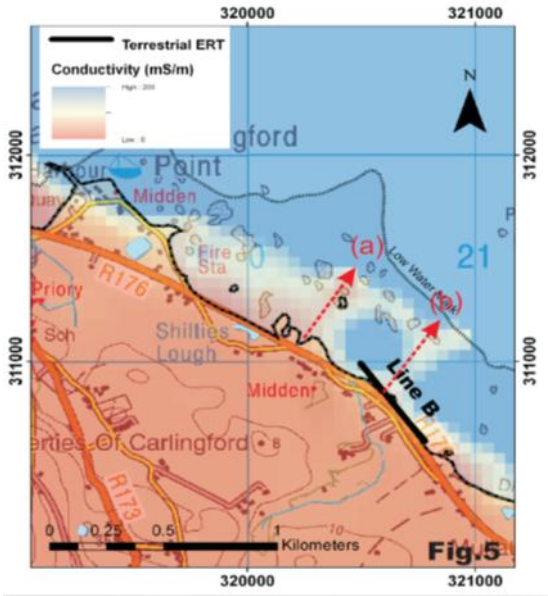


Figure 1 Possible indication of offshore freshwater discharge in coastal airborne geophysical EM data. From O'Connell and Daly (2013).

airborne electromagnetic (EM) data has been used in two research projects to investigate groundwater pollution and coastal groundwater. A postdoctoral research project at Queen's University Belfast looked into the use of airborne electromagnetic (EM) data to assess groundwater pollution plumes at landfills, based on the observation that contaminants can alter the conductivity of subsurface water. Case-studies of five landfill sites led to the conclusion that airborne EM data can be used to guide surface geophysical investigations in order to target intrusive ground investigations. EM data are thus a useful supplement to existing tools used to identify, characterise and monitor sites affected by landfilling activities and groundwater pollution.

Another research project completed at NUI Galway used airborne EM data to help identify potential zones of saltwater incursion into coastal aquifers and offshore freshwater discharge occurrences. Future planned survey phases in the coming years aim to complete coverage nationally, including areas of major groundwater interest such as the Curragh (major gravel aquifer) and the Burren (karst system with offshore groundwater discharge).

Although chemical characterisation of groundwater is not undertaken directly as part of Tellus, samples of soil, steam water and stream sediment provide a rich dataset to assist in the understanding of the natural geochemical status of groundwater regionally – including identifying the natural and anthropogenic sources of chemical elements, and chemical and weathering processes at play in the surficial and underground environments. Sampling is undertaken on a regular grid at a typical density of 3 – 4 km^2, allowing regional geochemical trends relating to geology to be systematically identified at the 1:50,000 scale. This baseline, multi-element geochemical approach is different to the more familiar site-specific or catchment-specific monitoring that is usually carried out in

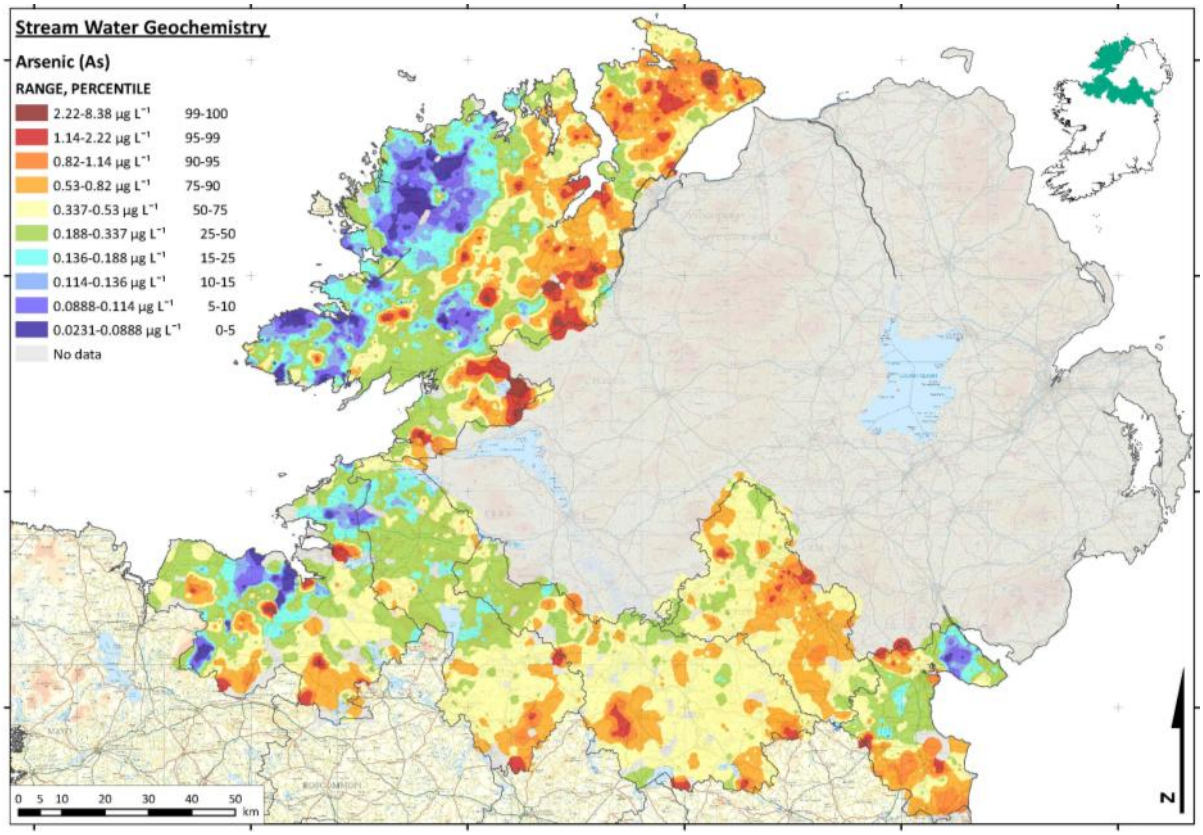


Figure 3 Tellus Border stream water arsenic concentrations

Table 1 List of chemical determinands for stream sediment, stream water and topsoil analysed for Tellus Border.

Sample type collected	Analytical method	Chemical determinands
Stream sediment (fine fraction, <150 µm grain size)	X-ray fluorescence spectrometry (XRFS)	K, Ca, Ti, Mn, Fe, S, Cl, Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Nb, Mo, Nd, Sm, Yb, Hf, Ta, W, Tl, Pb, Bi, Th, U, Ag, Cd, In, Sn, Sb, Te, I, Cs, Ba, La, Ce, Na, Mg, Al, Si, P, Ba, Y
	Lead collection fire assay for precious group elements	Au, Pd, Pt
Stream water (filtered to <0.45 µm)	;ICP-MS	Li, Be, B, Na, Mg, Al, Si, P, S, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Y, Zr, Nb, Ag, Cd, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Tb, Tm, Yb, Lu, Hf, Ta, W, Tl, Pb, Bi, Th, U, Ti, Mo, Gd, Dy, Ho, Er
	Ion chromatography	Cl^-, SO_4^{2-}, NO_3^-, Br^-, NO_2^-, HPO_4^{2-}, F^-
	Organic carbon (NPOC) analyser	C
	Stream water pH, specific electrical conductivity, total alkalinity (bicarbonate)	
Topsoil (*c*.5–20 cm deep)	ICP(-OES/-MS) following *aqua regia* digestion	Al, B, Ba, Ca, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, S, Sr, Ti, V, Zn, Zr, Ag, As, Be, Bi, Cd, Ce, Co, Cs, Ga, Ge, Hf, Hg, In, La, Lu, Mo, Nb, Pb, Rb, Sb, Sc, Se, Sn, Ta, Tb, Te, Th, Tl, U, W, Y, Yb
	X-ray fluorescence spectrometry (XRFS)	K, Ca, Ti, Mn, Fe, S, Cl, Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Nb, Mo, Nd, Sm, Yb, Hf, Ta, W, Tl, Pb, Bi, Th, U, Ag, Cd, In, Sn, Sb, Te, I, Cs, Ba, La, Ce, Na, Mg, Al, Si, P, Ba, Y
	Soil pH (by $CaCl_2$) and soil loss-on-ignition at 450°C	

support of specific water objectives such as the Water Framework Directive. For example, the 'regional snapshot' of surface stream water arsenic concentrations provided by Tellus shows strong similarities to those for soil and stream sediment, suggesting significant geological control of water chemistry. The geochemical data have the potential to inform understanding of regional, cross-border groundwater issues such as the provenance of natural potentially harmful elements (e.g. arsenic) and also to establish baseline chemical conditions in the context of future potentially polluting activities (e.g. shale gas extraction). The stream water database includes data for some 65 determinands, including organic carbon, pH, conductivity, alkalinity, major ions, trace metals and rare earth elements measured at low levels (Table 1).

Data from the border region is available free of charge to download and view at www.tellus.ie. Archive samples of water, sediment, panned sediment concentrates, vegetation, topsoil and subsoil are available on application. Data from the latest survey phase, Tellus North Midlands, will become available on a phased basis from September 2015. From time to time in the coming years Tellus will run research calls inviting researchers to undertake studies using Tellus data.

To be added to the Tellus mailing list to receive notifications of data releases, publications, research calls and events please email tellus@gsi.ie.

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The use of nitrate isotopes in understanding nitrate fate and transport in Irish agricultural catchments

Alison Orr , ARUP (formerly QUB)

Using N isotopes to identify sources and attenuation processes in two contrasting agricultural catchments - Glen Burn and Nuenna catchments. An output from the Pathways Project.

Introduction

Nitrate is considered to be the most significant groundwater pollutant of concern in Ireland. Excess nitrate in groundwater can lead to eutrophication when discharged to surface water bodies and remains one of the biggest environmental challenges in Europe. Therefore it is important to understand nitrate fate and transport to inform catchment management decisions and promote best practice to reduce the impact of nitrate on the environment.

The research presented in this article is part of a PhD which investigated the impact of hydrogeological setting on the fate and transport of nitrate in groundwater and surface water in Irish agricultural catchments. Nitrate isotope analyses were undertaken in both groundwater and surface waters, however this article will focus solely on surface waters.

Nitrate isotopes

Nitrogen has two stable isotopic forms, ^{14}N which accounts for 99.63% of the total terrestrial abundance, and ^{15}N which accounts for 0.37%. Although oxygen has three isotopic forms, only the most abundant ^{16}O (99.796%) and ^{18}O (0.204%) isotopes are considered (Clark and Fritz 1997). Isotopes are commonly reported as δ in units of parts per thousand (‰) of the heavier isotope to the lighter isotope relative to a known standard. During physical, biological and chemical reactions lighter isotopes (more depleted) react more readily than heavier isotopes (more

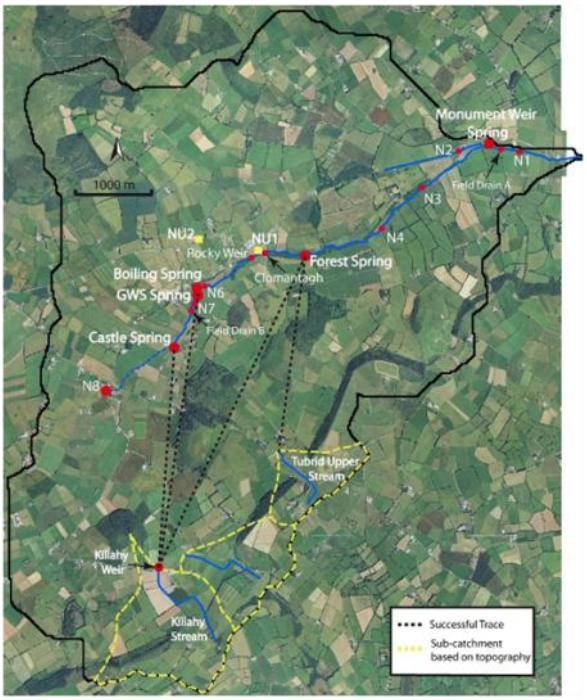

Figure 1 Nuenna catchment sampling locations and successful tracers carried out by Walsh (2011)

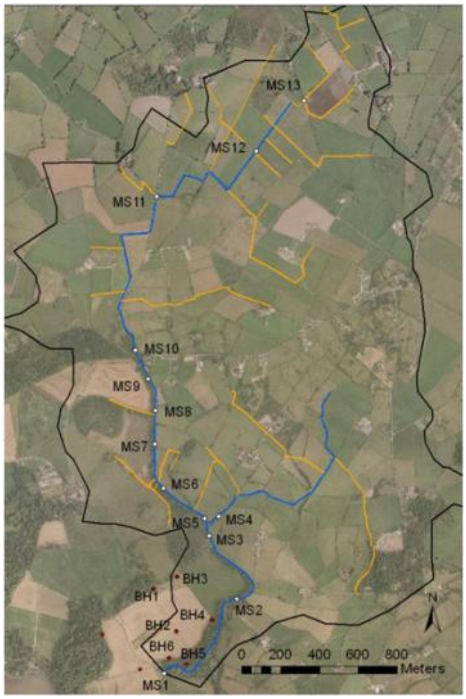

Figure 2 Glen Burn catchment surface water sampling locations

enriched) resulting in isotopically lighter products compared to reactants. This process is called fractionation and can produce unique signatures which are useful in identifying nitrate sources and biogeochemical processes.

Catchment descriptions

This research focused on two catchments; the Nuenna which is a well drained catchment underlain by a regionally productive diffuse karst (Rk_d) pure bedded limestone aquifer (Figure 1), and the Glen Burn which is a poorly drained catchment underlain by a poorly productive (Pl) Silurian greywacke aquifer (Figure 2). While both aquifers are fractured, transmissivity ranges are much greater in the Nuenna compared to the Glen Burn. The baseflow index of the Glen Burn stream is considerably lower (<0.13) than the Nuenna river (>0.87) (O'Brien et al 2013).

Despite the differences in hydrogeological settling the catchments do not differ greatly in terms of nitrogen loading which is approximately 400 kg N/ha/yr and the landuse is predominantly pasture in both catchments.

Nitrate isotopes and nitrogen dynamics in the Glen Burn Stream

Longitudinal profiles of N species concentrations, nitrate isotope values, flow and DO in the Glen Burn Stream were undertaken at extremely low baseflow conditions during the very dry summer of 2011 (Figure 3).

The headwaters (between MS12 and MS10) contained extremely low nitrate concentrations but relatively high organic N. This high organic nitrogen (ON) loading can be attributed to the greater amount of slurry spreading in the upper catchment. Due to anaerobic conditions at MS12, ammonification of organic N to ammonium was inhibited, resulting in no detectable ammonium (NH_4). The findings suggest that the dominant nitrogen pathway in the upper catchment is from point sources entering the stream via drains, overland flow and direct input from slurry spreading adjacent to the drains and stream.

A septic tank is located in the middle of the catchment. Downstream of the septic tank there is a further increase in ammonium, coupled with an increase in nitrate concentration and a decrease in organic N. This demonstrates that ammonification and nitrification was occurring, aided by the increase in dissolved oxygen (DO) concentrations. The increase in DO may be related to greater turbulence in the stream as bedrock became exposed.

The nitrate isotopic values detected downstream of the septic tank are within the ranges for septic tank and manure waste. However these values are relatively depleted suggesting partial nitrification.

Further downstream at MS7 the isotopic signature changed and the $\delta^{15}N$ became enriched while the $\delta^{18}O$ remained relatively similar. The enrichment of both isotopes would indicate denitrification. However as only the $\delta^{15}N$ was more enriched, this suggests an alternative nitrate source. Nitrate isotope values at MS7, MS2 and MS1 all fall within the isotopic signature range of the shallow groundwater indicating a contribution from the shallow groundwater. Considerably more enriched $\delta^{15}N$ values relative to $\delta^{18}O$ also indicate that the ammonium, from which the nitrate was derived, was influenced by volatilisation.

Similar to downstream of the septic tank, the isotopic values in the tributary were depleted and ammonium and nitrite concentrations elevated, suggesting partial nitrification. This implies that the source of nitrate to the tributary was relatively fresh, not having had enough time to undergo complete nitrification, or else the low DO in the tributary was inhibiting nitrification. Despite the difference in nitrate concentrations between the tributary and the main stream, at MS2 the isotopic groundwater signature of the main stream overprinted the signal from the tributary. This indicates that the overall influence of the tributary on the stream nitrate concentration is minimal at such low flow conditions.

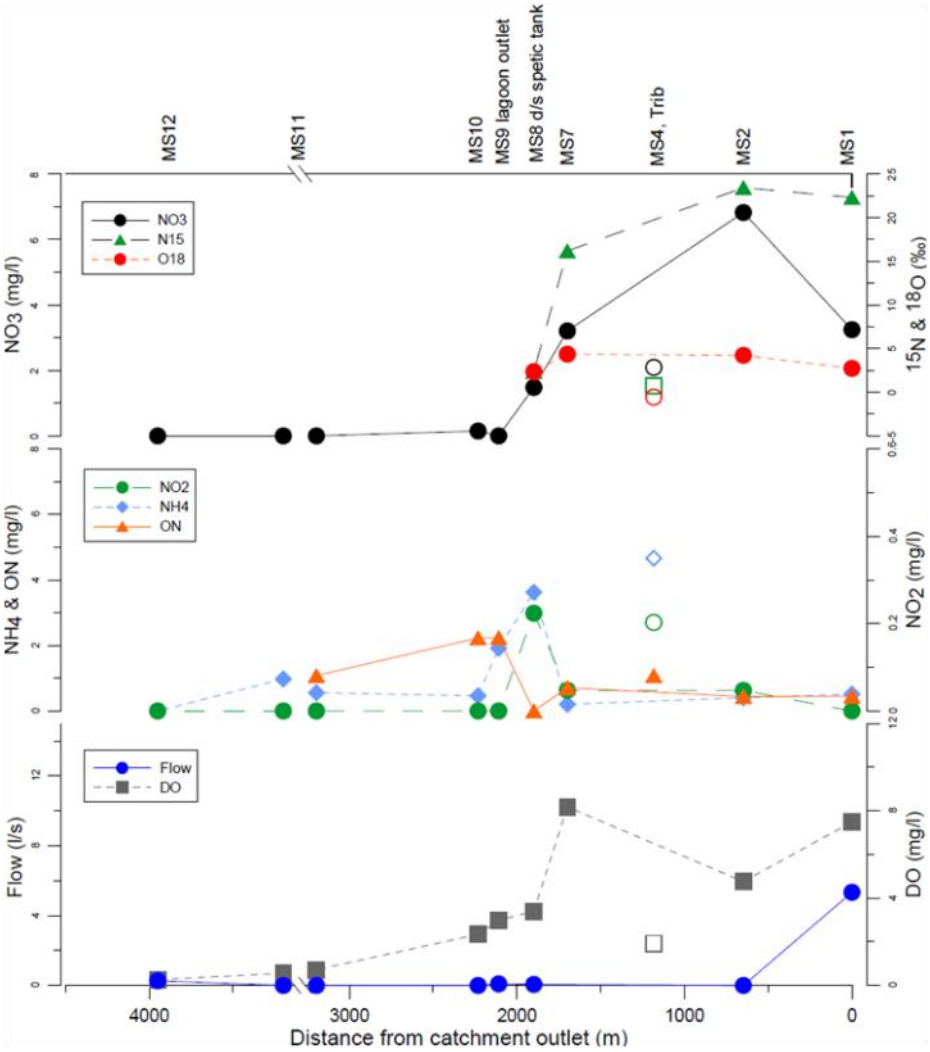

Figure 3 Longitudinal profile of nitrogen species, nitrate isotope values, flow and DO in the Glen Burn Stream

These findings show that point sources are a significant influence on this stream's water quality at low flows, particularly from organic N due to slurry spreading in the upper catchment. Furthermore nitrate speciation in the stream is highly influenced by biogeochemical processes and the changes in aerobic conditions within the stream.

Nitrate isotopes and nitrogen dynamics in the Nuenna Stream

The flow and nitrate dynamics in the Nuenna River are very different from those in the Glen Burn. Figure 4 shows the longitudinal profile of flow, nitrate concentrations and nitrate isotopic values during baseflow conditions in the Nuenna River. The dominance of groundwater in the Nuenna catchment is evident as the largest proportion of discharge to the river occurs at springs. A slight decrease in nitrate concentration along the river profile is evident however the concentrations remain relatively similar.

The range of isotopic values in the river are within the precision range for the method used which indicates that the sources and processes by which the river is fed are similar along the river profile. However, one exception exists at Forest Spring. The relatively depleted isotopic values in Forest Spring indicate a different source of nitrate compared with the sources for the other springs. Tracer tests carried out by Walsh (2011) have shown that Forest Spring is fed by a sub-catchment which does not discharge to the other springs (Figure 1). Although nitrate concentrations in Forest Spring are lower than in the main channel, the influence of this on the overall nitrate flux in the main river channel

is minimal due to the relatively low flow from Forest Spring.

The other springs in the catchment have also been traced to sub-catchments. Although these springs are derived from different areas, this has minimal influence on the nitrate fate on a catchment scale.

This is due to the high level of mixing and aerobic conditions in the groundwater which ensures nitrification is the dominant N biogeochemical process that is occurring.

This longitudinal profile highlights that point sources, such as septic tanks and livestock access locations, have minimal influence on river NO_3 concentrations in the Nuenna River.

Conclusions

Nitrate isotopes are a useful tool in identifying sources and attenuation processes occurring in Irish agricultural catchments. However, the findings from this research show that in catchments underlain by Rk_d aquifers, where nitrification dominates, the isotopes are most useful in identifying sources, whereas in catchments underlain by Pl aquifers, the isotopes are useful in identifying the attenuation processes in surface waters.

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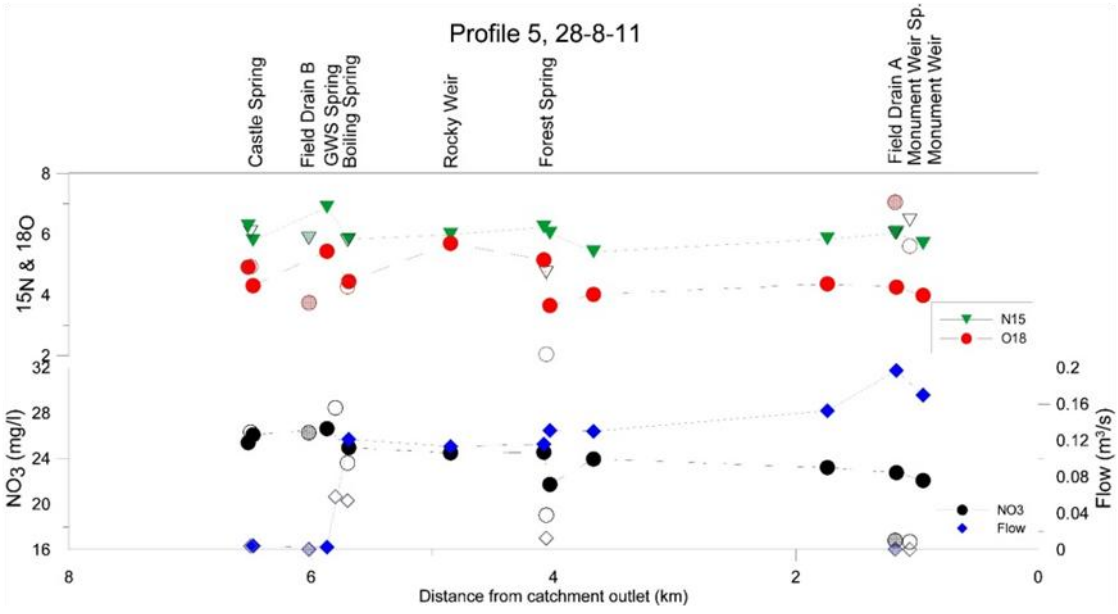

Figure 4 Longitudinal profile of N species concentrations, nitrate isotope values, flow and DO in the Nuenna River

Analysis of pumping test data using diagnostic plots for selected water wells in Ireland

Ahmed Thamer Ahmed[1, 2] · Bruce D.R. Misstear[1]
[1]Trinity College Dublin; [2]O'Connor Sutton Cronin Consulting Engineers

Using diagnostic plots, which are common in the oil industry, to improve the conceptual understanding of aquifer properties and well performances.

Introduction

Well pumping tests are the main means of obtaining information on key well performance and aquifer properties such as transmissivity (T) and storage coefficient (S). Conventional methods of analyzing well pumping test data usually involve plotting drawdown against time on semi-log scale (Cooper-Jacob) or drawdown against time on log-log scale (Theis plot) (Kruseman and de Ridder, 1990). These standard methods are often applied without much thought being given to their underlying simplifying assumptions, assumptions which are seldom met in practice (Misstear et al., 2006). This is especially a problem in Ireland where the bedrock aquifers are characterised by heterogeneous fracture flow systems rather than the idealised homogeneous and isotropic aquifers assumed when applying the Cooper-Jacob and Theis methods. The sand and gravel

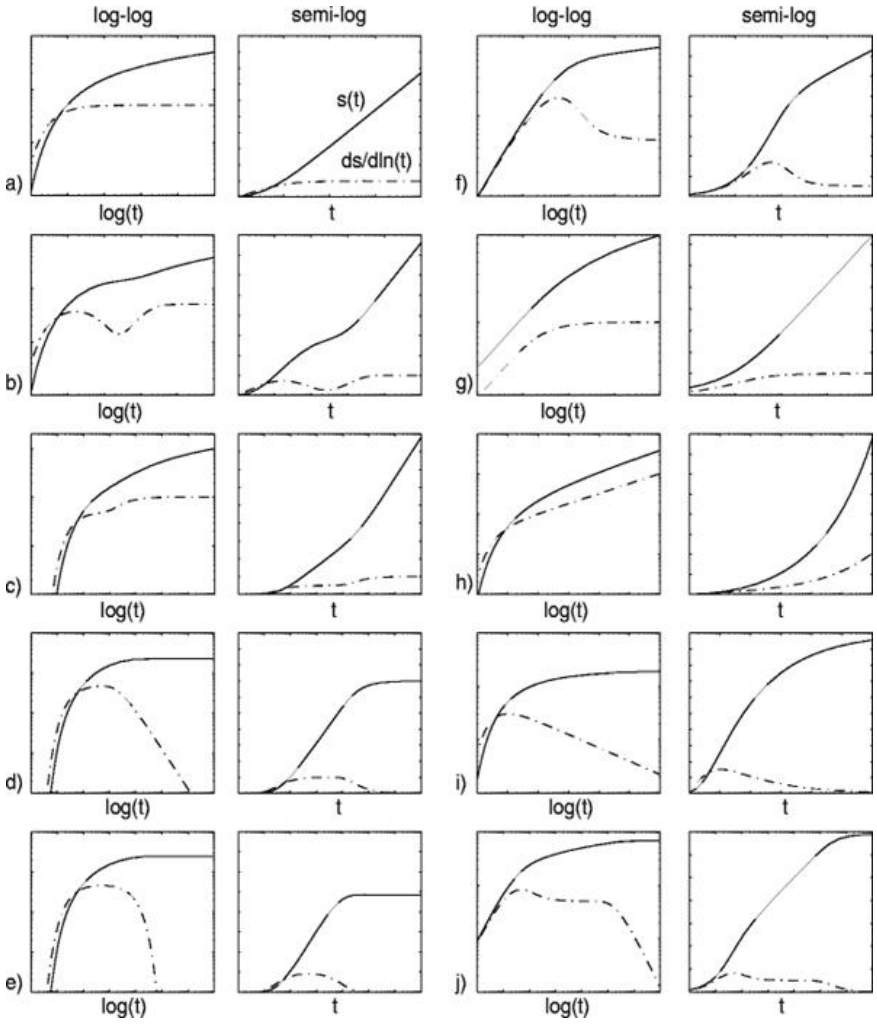

Figure 1: Most typical diagnostic plots encountered in hydrogeology: (a) confined aquifer; (b) double porosity or unconfined aquifer; (c) no-flow boundary; (d) linear constant head boundary model; (e) leaky aquifer; (f) well-bore storage and skin effect; (g) infinite conductivity vertical fracture.; (h) general radial flow—non-integer flow dimension smaller than 2; (i) general radial flow model—non-integer flow dimension larger than 2; (j) combined effect of well bore storage and infinite linear constant head boundary (Renard et al., 2009)

Table 1: Aquifer and pumping test details

Borehole designation and location	Knocks borehole, Co. Laois	Oliver's cross borehole, Co. Cork	Portmarnock, Co. Dublin
Pumping test duration (minutes)	220	660	7900
Maximum drawdown (m)	14	5.44	3.88
Pumping rate (m^3/day)	612	855	87
Well diameter (mm)	254	152.4	150
Aquifer type	Sand and gravel	Fractured limestone	Sand and gravel
Aquifer condition	Unconfined	Unconfined	Unconfined
Well Specific capacity (m^3/day/m)	40	157	23
Depth of well (m)	48	36.6	9.5
Depth to bedrock (m)	36	>12	-
Pre pumping water level (below ground level) (m)	4.56	17.74	2.3
Pumping water level (m)	18.5	23.18	6.18

aquifers in Ireland also tend to be heterogeneous. In the oil industry, diagnostic plots have been used for many years to aid in the analysis of well test data, but their usage in hydrogeology is less common. Diagnostic plots show the derivative of drawdown (rather than drawdown) plotted against time, on log-log or semi-log axes. The fundamentals of calculating the logarithmic derivative of drawdown are described by Renard et al. (2009). This paper also (i) shows how radial flow segments can be extracted from pumping test data by identifying the segments where the drawdown derivative is constant with time; these are termed Infinite Acting Radial Flow (IARF) periods and (ii) provides a catalogue of diagnostic plots for conditions that are commonly encountered in hydrogeology, as shown in Figure 1.

The typical diagnostic plot shapes facilitates the selection of a conceptual model when analyzing pumping test data (Renard et al., 2009). It should be noted that the shapes shown in Figure 1 are not comprehensive and other shapes may occur, for example when there is a combination of factors influencing the shape.

In the present study, diagnostic plots were prepared for three borehole pumping tests, at the sites indicated in Table 1.

Case Study 1: Knocks Borehole (Sand and Gravel Aquifer), Co Laois

It can be seen from Figure 2 that the early time drawdown data (black squares) for the Knocks borehole test fall on a Theis type curve, but that the later time drawdowns are less than the drawdown predicted by a Theis type curve. Insights on the cause of this response can be gained from the diagnostic plot, which is also shown in Figure 2 (as red circles). By comparing the shape of the diagnostic plot in Figure 2 with the catalogue of typical diagnostic plots shown in Figure 1, the diagnostic plot for the Knocks borehole resembles the curve in Figure 1(d),

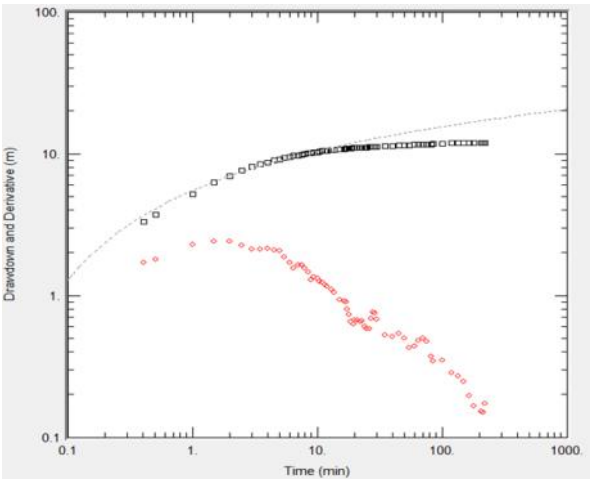

Figure 2: Drawdown (black squares) and its logarithmic derivative (red circles) on log-log scale for Knocks borehole

which is the linear constant head boundary model.

The linear constant head boundary model is characterized by falling of the drawdown derivative linearly with time until it reaches zero in late time; this characteristic can be observed in the Knocks borehole data. Since the diagnostic plot is the derivative of drawdown which is the slope of drawdown with time hence when it is becoming zero, this means that the drawdown is becoming constant with time which signifies recharge effects. This behaviour is attributed to recharge from a stream which is about 50-100 m away from the borehole according to site inspection reports.

Case Study 2: Oliver's Cross Borehole (Fractured Limestone Aquifer), Co Cork

This is a highly productive borehole tapping a fractured Carboniferous limestone aquifer. The log-log drawdown and drawdown derivative plots are included in Figure 3. The squares represent the drawdown and the red circles represent drawdown derivative. The figure shows that the derivative is increasing linearly in the first few minutes and then becomes almost constant throughout the remainder of the pumping test. Again comparing the shape of the derivative with the catalogue of typical diagnostic plots it can be seen that the shape of derivative in Figure 3 looks most similar to the example in Fig 1 (g), which is the case of a vertical fracture of finite extension but with an infinite conductivity. The model is characterized by the early period of the pumping test where the effect of flow in fractures dominates the response to pumping and there is constant gap between the drawdown and drawdown derivative; after a certain period the solution tends toward a Theis radial flow model which is proven by the near stabilization of the derivative from the 10th minute towards the end of the pumping test. Note that a Theis type curve can be fitted to the drawdown data; however, the derivative is never constant except towards the end which suggests that the flow is not perfectly radial.

Case Study 3: Portmarnock (Sand and Gravel Aquifer), Co Dublin

Figure 4 illustrates the diagnostic plot of the data from a sand and gravel well in Portmarnock which was pumped at a constant rate for 132 hours, with the red circles representing the derivative of drawdown. The shape is similar to that shown in Figure 1 (b), which is an unconfined aquifer with delayed yield. It can be observed that the derivative is almost constant from the first minute to the 800th minute then it goes through a transition period which appears as a low in the derivative curve, and then it is almost constant again till the end of the test. As mentioned earlier, the periods where the derivative is constant are termed as 'infinite

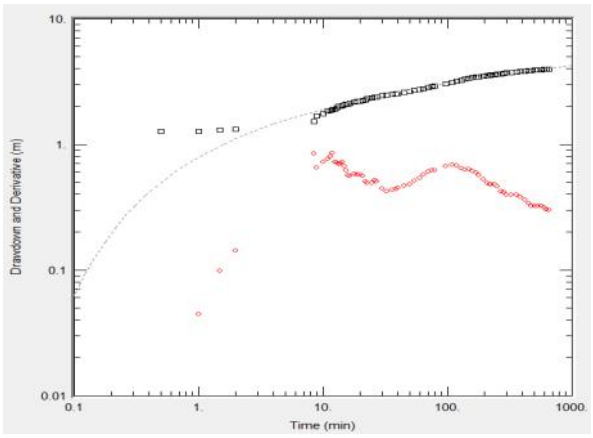

Figure 3. Drawdown and derivative on log-log of the pumping well

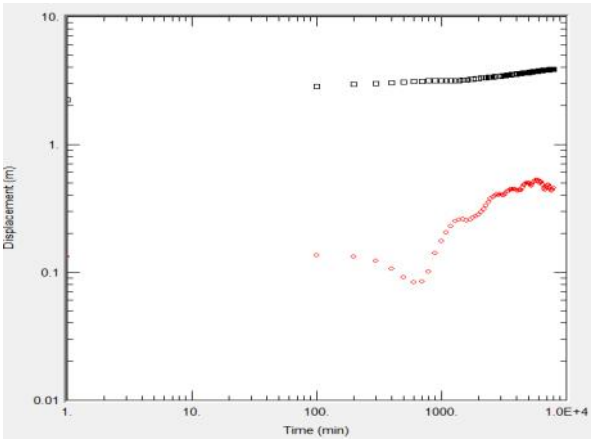

Figure 4. Diagnostic plot of Portmarnock drawdown data

acting radial flow (IARF) periods'. The advantage of using a diagnostic plot is that it amplifies the behaviour of the time-drawdown data and the changes are clearer on the diagnostic plot than on the normal log-log plot. The model suggested by the diagnostic plot of an unconfined aquifer with delayed yield is justified by the presence of two radial flow periods which conforms to a Theis model and one intervening delayed yield period between the two IARF periods, which is a typical behaviour of unconfined aquifers.

Conclusions

This article provides a brief outline of the potential usefulness of diagnostic plots under Irish conditions. It would be worthwhile following up this short study by applying the method to data from other pumping tests, especially tests carried out on boreholes in the fractured rock aquifers that are most commonly found in Ireland. As with any hydrogeological analysis, good interpretation relies on having good data (see acknowledgements below). For diagnostic plots, the drawdown derivative is very sensitive to any sudden changes in well pumping rate, which must be kept constant throughout the test.

Acknowledgements

The authors would like to express their gratitude to the Geological Survey of Ireland and to Coran Kelly, David Ball and Richard Langford for providing the test data.

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Peatland Restoration: Using hydrological and hydrogeological research to answer questions and resolve disputes.

Raymond Flynn[1], Francis Mackin[1,2], Alister Best[1], Hugh Cushnan[1] and Shane Donohue[1]
[1]Queen's University Belfast; [2]RPS consulting engineers

Recent estimates suggest that since 1994 approximately 39% of active raised bog has disappeared from protected areas. Researchers at QUB are developing sustainable solutions.

If you were to ask visitors to Ireland some years ago what struck them most about the Irish countryside, many would have remarked on our mountains, lakes and bogs. Since then, although our mountains and lakes remain familiar elements of the landscape, the same cannot be said for many of our bogs. The last 60 years have witnessed a dramatic decline in the area of high (uncut) bog , and more particularly areas hosting peat accumulating plant communities on raised bogs (also known as active raised bog). Recent estimates suggest that since 1994, approximately 39% of the active raised bog has disappeared from protected areas. Addressing this loss presents considerable challenges. European Union Habitats Directive requirements to restore active raised bog, or to provide alterative habitat to compensate for losses within protected sites, have prompted researchers at Queen's University Belfast, working in collaboration with RPS Consulting Engineers, to investigate this matter further and develop sustainable solutions that meet needs at both EU and local community level.

Improving current understanding of hydrological

Figure 1 Blocking drains on formerly afforested raised bog aims to raise the water table and permit peat accumulating vegetation to re-establish. Providing appropriate supporting conditions is essential for stable raised bog ecosystems.

and hydrogeological supporting conditions, required to allow active raised bog to survive, forms the cornerstone of restoration programme research. Raised bog hydrological modelling carried out to date, suggests that conventional intervention measures, such as limiting further turf cutting or installing dams in high bog drains, will prove insufficient to restore approximately 230 ha of active raised bog that could have been restored in protected areas in 1994. What's more, where hydrological conditions continue to deteriorate further losses can be anticipated if no action is taken. These findings have led to consideration of additional intervention measures to supplement existing approaches; these include restoration programmes on cutover raised bog and on formerly afforested high bog (Figure 1).

Although restoration programmes are necessary to restore peat accumulating conditions, applying sustainable solutions also requires consideration of impacts to local communities. Stakeholder responses to proposed restoration programmes have proven controversial in some areas. To address this issue, studies using digital environmental datasets have identified areas where turf cutting may possibly be allowed to occur without further impacting on remaining active raised bog or proposed restoration works. Forthcoming field hydrogeological investigations will provide critical supplementary information for quantifying the effects of localised cutting on bog hydrology; these effects can extend tens of metres to hundreds of metres from a cutting face into the high bog, depending on peat substrate hydrogeological conditions and extraction techniques employed.

So far research findings have improved our current understanding of raised bog hydrology and hydrogeology, and our ability to decide whether particular restoration strategies will prove feasible. At the same time investigative techniques developed by the research team display considerable potential both for applications to other peatland habitats requiring restoration, and for addressing emerging issues, such as the impact of wind farm developments on peatland ecology. The current programme of activities will continue over the next three years and promises to further deepen our understanding of interrelationships between water and wetland ecosystems, while also considering impacts of conservation measures on local communities.

Development of wells on a peninsula: the challenge of preventing sea water intrusion

Sara Raymond, Monika Kabza and Nicola Salviani
Geological Survey of Ireland and Tobin

This is the first official Early Career Hydrogeologists' Network (ECHN) article in the Groundwater Newsletter. The editors hope that it will become a regular feature. Here, three ECHs describe their field-work experience with independent hydrogeologists David Ball and Richard Langford.

Introduction

At the beginning of summer 2014 we had the opportunity to observe and take part in developing a network of wells. The wells, located on a peninsula, needed to provide a minimum of 800,000 litres of water per day for irrigation. The challenge was to prevent sea water intrusion into the fresh water aquifer. This was accomplished by drilling ten shallow wells as close to peninsula centre as was practicably possible to moderate the effect of the drawdown.

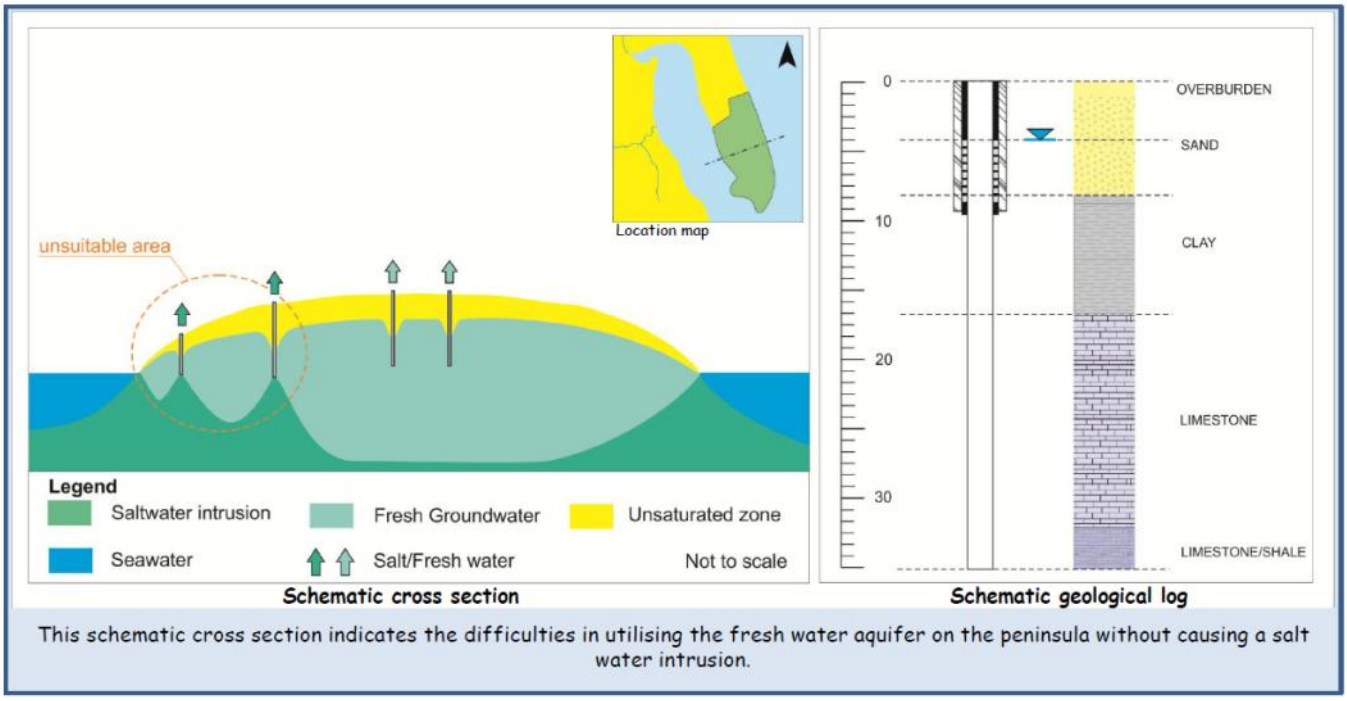
We spent three days on site looking at a few different phases of the project:

- We observed the well drilling process and we took part in well development.
- We learned how to develop the wells using the air-lift pump technique.
- We helped to 'fix' one of the wells, which was damaged during its development.
- We did a step-drawdown pumping test for one of the wells.

Geology

The peninsula is underlain by limestone and shale bedrock and is covered by boulder clay and fine sand. The thickness of the boulder clay depends on the topography of the underlying bedrock. The unconsolidated sand aquifer (9 - 15m thick) is recharged mainly by rainwater.

Knebel drilling rig



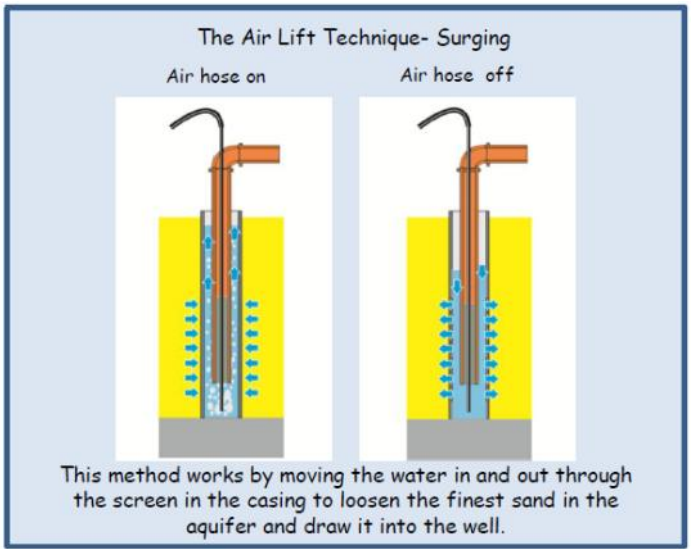
This schematic cross section indicates the difficulties in utilising the fresh water aquifer on the peninsula without causing a salt water intrusion.

Drilling & Development

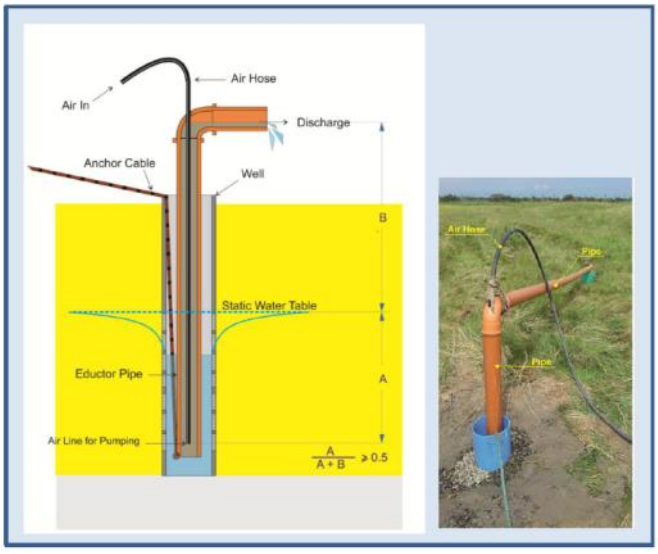
To test the suitability of the bedrock aquifer for the project a well was drilled into the limestone. During the pumping test conductivity was steadily increasing and there were fears that continued pumping could lead to an intrusion of seawater into the fresh water aquifer. So to meet client demand and to prevent contamination of the fresh water aquifer it was decided to abstract water solely from the unconsolidated sand aquifer.

The drilling rig used was a Knebel Drilling A/S HY-97T-BR. This very impressive machine is a semi-trailer mounted drilling rig, designed for drilling to a depth of more than 400m, and a hole diameter from 6" to 24" max.

The wells were drilled with a 12" drill bit to a depth of approximately 9.8m. Then lined with 12" plastic casing with screen, which was covered with a geotextile filter (called 'tights' by drillers). The Geotextile filter/'tights' was used to prevent sand from entering the well through the screen and building up in the wells.



This method works by moving the water in and out through the screen in the casing to loosen the finest sand in the aquifer and draw it into the well.



'Fixing' the well

Putting the 'tights ' on the casing.

Lifting the 8" casing into the well

Filling the gap between the casings with coarse sand

Putting the pump into the well

Once the drilling was completed and the casing had been inserted, we had the opportunity to develop one of the wells. As the sand in the aquifer was very fine, it was necessary to remove the finest particles from the well, to prevent both damage to the pump and sand build up in the wells.

We began by setting up the equipment to start 'cleaning the well' using the air-lift pumping technique.

The equipment was surprisingly simple; all that was needed was a few PVC pipes, air hose, air compressor and some basic tools like a saw, hammer, knife, some string and a mirror. The pipes were placed down into the well, their length calculated to be able to reach to the full depth, and from the bend in the middle the pipes were laid along the surface to carry the water away from the well during pumping. Then we inserted the air hose down the well through the pipes. Entering the air hose required caution, as there was a risk of damaging the "tights" at the bottom of the well. And now the fun part started – surging and pumping.

To surge the well the air compressor was turned on to the maximum for ~2-4 seconds and as the water reached the top of the casing it was turned off again and the water level dropped. This was done repeatedly and drew in the fine sand particles. If the air was left on too long the water would shoot up out of the well creating a 'fountain' (which would soak anyone, who was unfortunate enough to be standing close by). When the water became cloudy it was then pumped out by leaving the air compressor on at a lower constant rate. This process could be repeated until the water was no longer too cloudy after surging. During pumping the air hose must be inside the pipe, however during surging it must protrude out the end of the pipe to allow air enter the well.

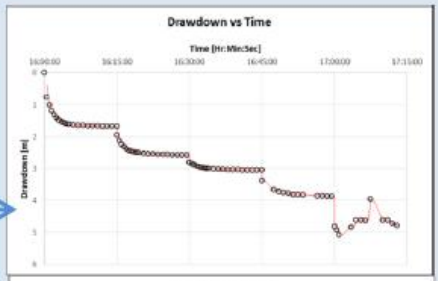
While pumping, we frequently took the conductivity of the water to check whether it had increased - just to check there was no salt water intrusion.

The Air-lift method worked well in all the wells but one, where after surging and pumping for a considerable time, the amount of sand being brought up was not decreasing at all. This was thought to be due to a small tear in the geotextile. Luckily the well diameter was 12'' so we could insert an 8" diameter casing to remedy the problem. This gave us a chance to put the 'tights' on the casing and then lowered it down into the well. It was decided to use coarse sand to fill the gap between the casings. This was fun as two of us had to 'spin' around the well, one with a hammer and the other with the sand

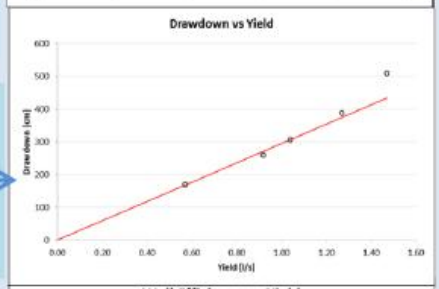
Pumping Test Data

minutes	Flow rate 0.57l/s Water Level 1	Flow rate 0.92l/s Water Level 2	Flow rate 1.04l/s Water Level 3	Flow rate 1.27l/s Water Level 4	Flow rate 1.47l/s Water Level 5
0	2.14	3.82	4.72	5.19	6.01
0.5	2.9	4.09	4.85	5.36	-
1	3.14	4.26	4.94	5.45	-
1.5	3.33	4.39	4.99	5.51	6.77
2	3.46	4.46	5.03	-	6.95
2.5	3.55	4.525	5.065	-	7.07
3	3.62	4.57	5.09	-	7.23
3.5	3.67	4.6	5.1	-	-
4	3.7	4.62	5.12	5.8	-
4.5	3.73	4.64	5.13	-	-
5	3.75	4.65	5.135	5.87	-
6	3.77	4.67	5.14	5.9	6.98
7	3.79	4.68	5.155	5.92	6.76
8	3.795	4.69	5.16	5.95	6.76
9	3.8	4.695	5.165	5.96	6.77
10	3.805	4.7	5.17	5.97	-
11	3.81	4.705	5.175	-	6.1
12	3.815	4.71	5.18	-	6.76
13	3.82	4.71	5.18	6	6.76
14	3.82	4.715	5.19	6	6.86
15	3.82	4.72	5.19	6.01	6.92

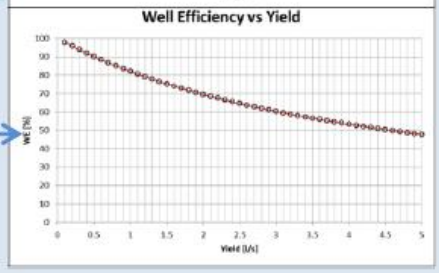
Using this data it is possible to show the relationship between the water level and time.



It is also possible to determine the optimum pumping rate.



And the efficiency of the well.



bucket. This ensured that the sand was distributed evenly and prevented it from bridging. We cleaned the well and started the pumping test.

Hydraulic Testing

We needed a water dipper, stop watch, paper, pen and of course a pump to start the test. To begin with we inserted the pump into the well. We were advised of the initial pumping rate. Each of us took responsibility for one aspect of the test (measuring the water table, taking the time and recording the data). The test ran smoothly at first however towards the end it became difficult to take water level measurements. This was due to water entering through the screen above the water level and falling on the dipper which as a result gave false readings. The purpose of the step drawdown test was to determine the most efficient pumping rate for a well. The optimum pumping rate was between 1-1.5l/s (~80,000l/d).

The project hydrogeologists' decided to install a total of ten wells throughout the peninsula. This spreads the effects of drawdown which prevents a saline intrusion.

This fieldwork experience has been educational. We learned a lot from hands on experience. We had excellent guidance from the really patient hydrogeologists on site. We became familiar with a well development, pumping test and a hydrogeologist role during drilling.

Acknowledgments

We would like to thank everybody at the GSI for their help and especially David Ball and Richard Langford, for their encouragement and patience.

New Research in Hydrogeology

This section of the Irish Groundwater Newsletter contains summary reports on hydrogeological research being carried out in Ireland. Many thanks to the individuals who coordinated the reports from each institution. If you know of research which should be included please contact the editors at groundwaternewsletter@gsi.ie.

Research

Coordinator: Catherine Dalton

Jean O'Dwyer completed a Doctor of Philosophy in 2015 in the Chemical and Environmental Science Department (University of Limerick). The research investigated the ***microbiological status of potable, private, well water***. The hydrology, hydrogeology and anthropogenic pressures of the sampling locations were analysed using GIS and statistical modelling, and identified areas of high vulnerability. The study aimed to facilitate both public health authorities and environmental bodies to classify areas based on polluting potential for future development of water infrastructure. The research was conducted under the supervision of Catherine Adley.

Publication: O'Dwyer, J., Dowling, A., & Adley, C. C. (2014). Microbiological assessment of private groundwater-derived potable water supplies in the Mid-West Region of Ireland. Journal of Water and Health, 12(2), 310-317.

Catherine Dalton, Geography Department (Mary Immaculate College) recently advertised a PhD scholarship to commence in 2015 entitled 'A palaeolimnological assessment of reference ***conditions at Lough Gur***, Co Limerick, to inform catchment management and lake restoration'. The water quality in Lough Gur is classed as hypertrophic by the Environment Protection Agency and the underlying diffuse flow karst aquifer makes the lake extremely vulnerable to contamination. The project aims to contribute data on the onset of nutrient enrichment. The project will be co-supervised by Norman Allott (Trinity College) with inputs from Richard Langford (Parkmore Environmental Services) and Anne Goggin (Limerick City and County Council).

Publication: Dalton, C. & Langford, R. (2014) The geography of Lough Gur. In Dalton, C. and OCarroll, E. (Eds.) (2014) Limerick and Shannon Estuary Region, IQUA Field Guide No. 32, Irish Quaternary Association, Dublin. ISBN: 978-0-947920-46-3.

Tiernan Henry

Earth and Ocean Sciences staff, Tiernan Henry and Liam Morrison, are co-PIs (with Prof Frank McDermott in UCD) on two iCRAG PhD studies, set to start autumn 2015. Both projects are focused on better understanding the distribution of ***metals in groundwater*** in Ireland. This links with ongoing work at NUIG funded by the Griffiths Award. Ellen McGrory is completing her PhD on ***arsenic*** distribution with field work in Mayo and north Louth. We are completing a report on the north Louth part of the project with consultant Peter Conroy and the GSI.

Yvonne O'Connell is completing her Griffiths' funded PhD and is currently preparing a paper based on work we have been doing on the ***Dromiskin sand and gravel aquifer*** in mid-Louth. Yvonne has extracted a body of information from the TELLUS data and we have recovered surface and groundwater samples from wells

and ditches in the area. We will be doing some resistivity work in the area over the summer and are preparing a paper (Colin Brown, Eve Daly & Tiernan Henry) on modelling the hydraulic conductivity and porosity variations with depth in the overburden.

Sarah Blake's PhD (IRETHERM project – SFI funded) on ***thermal springs to the west of Dublin*** will be completed this year. The results of multivariate statistical analysis of the chemistry data from the sampled springs form the basis for a paper which is currently in preparation. The findings from the hydrochemical analysis are supported by detailed temperature profiles and geophysical surveys. Sarah has presented her findings at IGRM, AGU and EGU.

Sara Vero (TEAGASC Walsh Fellow) is also nearing completion of her PhD. She is co supervised by Mark Healy (Civil Engineering, NUIG) and Tiernan Henry (EOS, NUIG) and is working on ***soil water characteristics*** and assessing equilibrium in soil drainage. She is currently revising a paper submission to the Soil Science Society of America Journal.

Tiernan Henry is starting a School of Natural Science-funded project looking at the chemistry of the flooded pit at the ***Tynagh Mine***. Samples will be recovered at various locations and from a range of depths across the pit.

John Walsh

There are currently 3 main research groups performing groundwater-related research in UCD. Together they provide a relatively diverse range of research programmes on groundwater studies, which are conducted in the School of Civil, Structural and Environmental Engineering and in the School of Geological Sciences.

The UCD Dooge Centre for Water Resources Research has produced a ***new catchment model*** (SMART) designed specifically for ***simulating the transport of nutrients from rural catchments to water bodies***. Produced as part of a larger EPA-funded "Pathways" project involving UCD, TCD and QUB, special attention has been paid to differentiating between the water flows and nutrient transport (mainly Nitrogen and Phosphorus) and attenuation in the surface runoff, subsurface drains, interflow, and groundwater flow paths. The model parameters have been linked to physical features of the catchment so it can be applied to ungauged catchments. A particular feature is its description of the flowpaths using a flexible node-link network structure. This allows the possibility of altering the surface and subsurface connectivity in a sub-catchment or between sub-catchments as appropriate. It also offers possibilities for validating the model and some of its flow-path splits using measured groundwater levels and initial results of this and of splits determined from end-member analysis, done by TCD, have been encouraging.

The Paleoclimate Research Group at the UCD School of Geological Sciences has focused on ***shallow-level groundwater recharge*** through the vadose zone of karstified Carboniferous limestone systems in counties Kerry and Waterford. Stable isotope (d18O) and trace element tracers as well as continuous time-series measurements of seepage flow rates have been used to investigate spatial and temporal variations in the residence times of recharging waters in soils, glacial tills and the shallow epikarst zone, with implications for the transit times of surface derived pollutants to groundwater bodies. More recently the group has investigated selected ***geogenic metal contamination in groundwaters*** from a range of geological settings in Ireland, with a particular focus on ***uranium and arsenic***. This work will be developed further as part of the newly formed

SFI-funded Irish Centre for Research in Applied Geosciences (iCRAG).

The Fault Analysis Group, also from the UCD School of Geological Sciences, performs research on the ***impact of fractures and faults on groundwater flow***, mainly in the context of an EPA Strive Programme funded PhD project conducted by John Paul Moore, in collaboration with GSI and QUB. This study involves quantitative analysis of the different types of fault and fracture systems in the broad range of Irish bedrock types, focussing on developing generic conceptual models for fault/fracture systems in different lithological sequences and at different depths, and linking them to observed groundwater behaviour. A variety of attributes/ parameters, all of which are critical determinants of the flow behaviour and pathways of such systems, have been defined from high quality natural outcrops, quarries and mines, including fracture orientations, densities, spacing/clustering, sizes (length/aperture/ thickness), scaling and connectivity. The resulting structural geologic conceptual models and parameterisations have been linked to observed groundwater behaviour using flow constraints mainly derived from mine data and from GSI hydrogeological databases. This research will also be developed further as part of iCRAG.

Queen's University Belfast

Ray Flynn

Two research projects are currently underway in QUB. The Civil Engineering research centre (Raymond Flynn, Francis Mackin, Alister Best, Hugh Cushnan and Shane Donohue) are using hydrological and hydrogeological techniques to investigate peat restoration (see article on page 28). Contact: r.flynn@qub.ac.uk

A GSI/GSNI sponsored collaboration between QUB's Civil Engineering Research Centre (Raymond Flynn and Ruaidhri McKernon) and Dundalk IT (Victor Perello and Valerie McCarthy) is assessing risk to Groundwater Dependent Ecosystems in the Border Region. The project is using digital environmental data sets to investigate the risk posed to wetlands by rural pollution pressures. Contact: r.flynn@qub.ac.uk

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Laurence Gill

The Environmental Engineering research group in the Dept. of Civil, Structural and Environmental Engineering is carrying out an EPA funded project (ref. 2012-W-MS-12) to quantify the ***impact of on-site wastewater effluent on rivers and wells***. The groundwater related part of this project is focused on studying private wells across four different areas, two characterised as Low vulnerability (in Counties Wexford and Cavan) and two characterised as Extreme vulnerability (in Counties Wexford and Kilkenny). A total of 216 wells have been sampled for contamination as well as surveyed for pollutant source susceptibility. A number of these wells will be selected shortly for regular monitoring. In addition, the research is attempting to identify robust ***chemical and/or microbiological fingerprinting methods*** (in collaboration with the Dept. of Microbiology in NUIG) for on-site effluent contaminants in both surface water and groundwater environments. Contact: Chris Fennell (fennelca@tcd.ie), Bruce Misstear (bmisster@tcd.ie) and Donata Dubber (dubberd@tcd.ie).

Environmental Engineering also has an on-going postdoctoral fellowship funded by the Irish Research Council and the GSI in collaboration with the Swiss Institute for Speleology and Karst

Studies (SISKA) to ***develop numerical models of two Irish karst catchments*** using the KARSYS methodology (as developed by SISKA). The project is focussing on two areas, Bell Harbour catchment in the Burren and the Shanballymore/ Castletownroach spring catchments (north Cork). Contact: Ted McCormack (mccormte@tcd.ie).

Research by the group also continues into the transport and attenuation of on-site effluent contaminants with a new project in collaboration with the Dept. of Mathematics in Limerick to ***develop numerical models of pollutant transport*** from on-site systems to groundwater. Field sites are currently being constructed and instrumented in County Limerick in different soil types. Contact: Jan Knappe: (jan.knappe@tcd.ie).

A new research collaboration between Environmental Engineering and the Dept. of Geology has also just commenced on the lowland binary karst system in south Galway using ***rare earth elements as tracers of flow pathways*** into the main karst conduit network that discharges at Kinvara. Contact, Laurence Gill (laurence.gill@tcd.ie).

Meanwhile Bruce Misstear is working with Dave Banks on a ***second edition*** of their textbook ***Water Wells and Boreholes***. This is due to be published by Wiley next year.

Current research in the School of Natural Sciences includes a range of interdisciplinary projects on groundwater quality, groundwater-surface water interaction and groundwater-dependent ecosystems:

A joint TCD – Teagasc project, now in its third year, is being undertaken by Eoin McAleer on ***nitrogen attenuation along delivery pathways*** in agricultural catchments, under the supervision of Catherine Coxon (TCD), Per-Erik Mellander and Karl Richards (Teagasc), funded by a Teagasc Walsh Fellowship. Findings on denitrification along the hydrological pathways were presented by Eoin at the European Geosciences Union General Assembly and at the IAH Irish Group annual groundwater seminar in April 2015. Contact: Eoin.McAleer@teagasc.ie

Jean Wilson, a post-doctoral research fellow in the School of Natural Sciences, is undertaking an EPA STRIVE funded project (CONNECT) together with Carlos Rocha and Catherine Coxon, which seeks to develop tools to ***identify and evaluate groundwater discharge to Irish lakes and transitional / coastal waters***. The GIS and remote sensing components of the project are complete and the groundtruthing component involving geochemical tracing is currently in progress. A project workshop will be held in September 2015. Contact: jewilson@tcd.ie

Aoife Delaney is undertaking a Ph.D. project on ***ecology and hydrology of coastal dune slacks***, with Jane Stout and Catherine Coxon, with funding from TCD, NPWS and EPA. Part of this project involves monitoring of groundwater levels and groundwater quality in six dune slacks in Donegal from autumn 2014 till autumn 2015. Contact: amdelane@tcd.ie

Katie Tedd's EPA STRIVE fellowship on evaluation and interpretation of data from the ***EPA National Groundwater Quality Monitoring Programme*** for the Water Framework Directive (with Catherine Coxon and Bruce Misstear) is at the final reporting stages, with two research papers published and a third in preparation. Following from this, Katie and Catherine are providing hydrogeological input to another EPA STRIVE project being undertaken by Katherine Webster and Ian Donohue, on the development of an ecohydrology framework for ***setting environmental flow standards for Irish rivers***. A workshop for stakeholders will be held towards the end of this 10 month desk study in Autumn 2015. Contact: websterk@tcd.ie and teddk@tcd.ie

Finally, the Schools of Natural Sciences and Engineering in Trinity College are a major partner in the new SFI funded Irish Centre for Research in Applied Geosciences - ***iCRAG***. In the groundwater research "spoke" TCD will conduct a total of 7 research projects over the next few

years with 3 PhDs currently being advertised to start in September 2015 on the subjects of groundwater recharge and climate change, emerging organic contaminants and modelling karst systems. See: http://icrag-centre.org/

Karl Richards

Research

To characterise water quality fully on Irish landscapes research must look towards potential sources of pollution. As agriculture is one such source there is an extensive research program within Teagasc looking at how different farming systems affect water quality temporally and spatially at different scales. This article focuses on some new research projects.

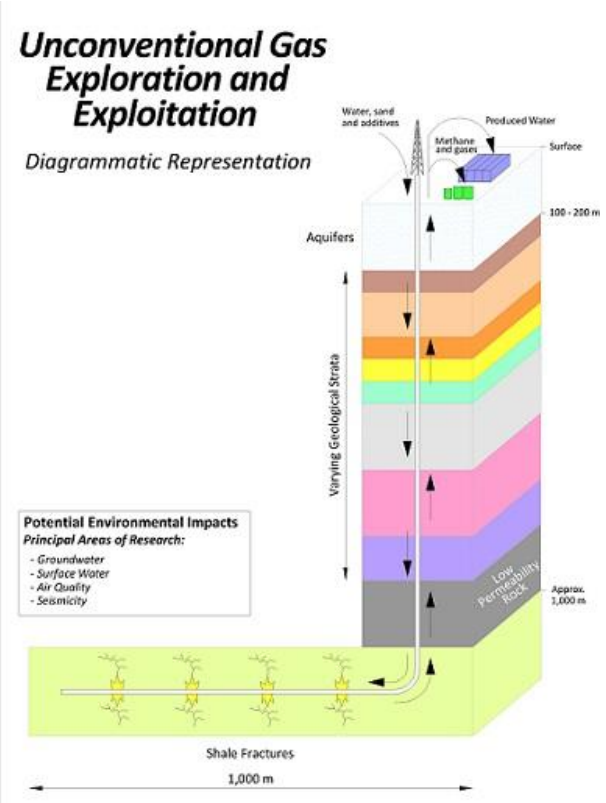
To understand the link between agricultural programmes of measures and water quality it is necessary to consider the ***residence time for water to move along different pathways*** to a receptor. This residence time or total time lag is broken up into different components and projects: 1) the ***unsaturated zone*** in association with NUIG and 2) the ***saturated zone*** in association with UCD. At present two PhD students are working on these components with fieldwork focusing on two borehole transects in two agricultural catchments. These modelling studies are being validated through field tracer experiments. Although it is recognised that agriculture can negatively impact water quality there is an understanding that this does not serve a farmers best interest, as nutrients lost to water represent a financial loss. Irish agricultural products are promoted internationally as sustainable and produced from lower intensity production systems compared to other countries. Improving water quality in Ireland is a key challenge that all farmers want to play their part in achieving but this must be done in an economically sustainable way. Research in Johnstown Castle has looked for win-win solutions where farmers can achieve their agronomic goals while at the same time protecting and enhancing the environment. The ***potential for natural attenuation of pollutants*** in groundwater has also been assessed to identify when additional changes are needed to improve water quality. There is also the potential to control mixed pollutants (e.g. nitrate and phosphorus) at key locations through precise delineation of critical source areas and connectivity pathways by coupling digital elevation models with permeable reactive interceptors.

Moving from farm to catchment scale has brought challenges in instrumentation and complexity which have been overcome through investment in the Agricultural Catchments Programme which is based in Johnstown Castle. There is research underway ***investigating groundwater nitrate attenuation through denitrification*** with initial results indicating that there can be considerable attenuation potential in some aquifers but this is spatially variable and can result in greenhouse gas emissions. Groundwater has also been highlighted as an important pathway for P loss within some catchments and there is a new PhD study with Ulster University to ***investigate the factors affecting the P source and transport pathways within the catchments***. Most focus nationally has been on nutrient occurrence in water. ***Veterinarian residues in groundwater*** has been found to be a problem in other European countries and a new PhD studentship with TCD, part of the new SFI Research Centre iCRAG, will investigate this in further.

The agricultural industry in Ireland has plans to expand production for the first time since the introduction of milk quotas over 30 years ago. The agricultural sector recognises the importance expanding in a sustainable manner and research will underpin this.

In addition to funding hydrogeological research projects (outlined on previous pages under separate university reports) the Environmental Protection Agency (EPA) has awarded a contract to a consortium led by CDM Smith Ireland Limited. They will carry out a 24-month research programme looking at the potential impacts on the environment and human health from ***Unconventional Gas Exploration & Extraction*** (UGEE) projects and operations (including construction, operation and aftercare).

The research programme is composed of five projects and will involve field studies (baseline monitoring of water and seismicity), as well as an extensive desk-based literature review of UGEE practices worldwide.



No fracking will be undertaken as part of the research programme.

The research programme has been designed to produce the scientific basis, which will assist regulators in making an informed decision about whether it is environmentally safe to allow fracking.

The key questions the research programme needs to answer are:

Can UGEE projects/operations be carried out in the island of Ireland whilst also protecting the environment and human health?

What is 'best environmental practice' in relation to UGEE projects/operations?

The programme comprises the following components:

Project A: Baseline Characterisation:
- Project A1: Groundwater, Surface Water and Associated Ecosystems
- Project A2: Seismicity
- Project A3: Air Quality

Project B: UGEE Projects/Operations: Impacts & Mitigation Measures

Project C: Regulatory Framework for Environmental Protection

The research programme is funded by the EPA, the Department of Communications Energy and Natural Resources (DCENR) and the Northern Ireland Environment Agency (NIEA).

The research is being carried out by a consortium, led by the global environmental and infrastructure management firm CDM Smith Ireland Limited. The consortium includes Queens University Belfast, British Geological Survey, University College Dublin, University of Ulster, AMEC, and Philip Lee Solicitors.

For further information see: www.ugeeresearch.ie

Hydrogeological News

This section of the newsletter contains news of interest to hydrogeologists in Ireland. It includes short reports on the recent activities of the IAH Irish Chapter as well as the IAH International. It also includes other groundwater related material such as new publications that may be of interest and where groundwater features in the media. If you are involved in, or aware of, any items which may of relevance for this section of the newsletter please contact the editors at groundwaternewsletter@gsi.ie

EPA launches DROPLET

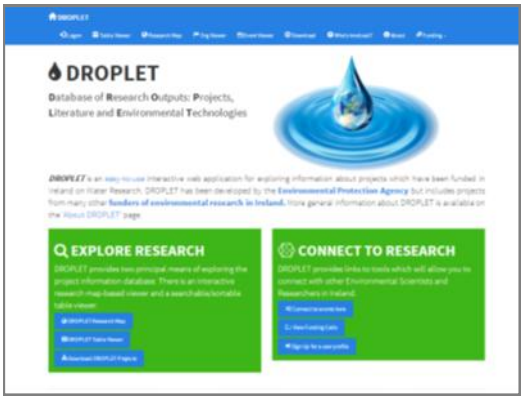
The EPA has recently launched its new interactive web application **DROPLET** for exploring information on Water Research projects funded in Ireland.

DROPLET is an easy-to-use interactive web application for exploring information about projects which have been funded in Ireland on Water Research. DROPLET has been developed by the Environmental Protection Agency but includes projects from many other funders of environmental research in Ireland.

DROPLET is available at:
http://erc.epa.ie/droplet/

Are your water-related projects listed on DROPLET? If not - Please register to submit the information on your projects!

Comments on the new interface are welcomed at: dropletadmin@epa.ie



IGI involved in KINDRA

As the national member association of the European Federation of Geologists (EFG), the IGI was contacted to participate in the KINDRA (Knowledge Inventory for Hydrogeology Research) project which is funded by the European Commission's HORIZON2020 Framework Programme.

The objective of KINDRA is to compile information about Europe's contemporary practical and scientific knowledge of hydrogeology research and innovation into a European Inventory of Groundwater Research (EIGR). The inventory will be used to identify and track future trends, critical challenges and research gaps, and will be developed following a new Harmonised Research Classification System (HRC-SYS). This system requires an effective assessment of the state-of-the-art of hydrogeology research across different geographical and geo-environmental settings, allowing for direct comparison and identifying synergies in groundwater research.

The project will contribute to improve management and policy development for groundwater resources at the EU level, coherently with the Water Framework Directive (WFD) and the Groundwater Directive (GWD). Following this classification, the EIGR will provide a public-access service for European hydrogeological research in progress.

For further information see:
www.kindraproject.eu

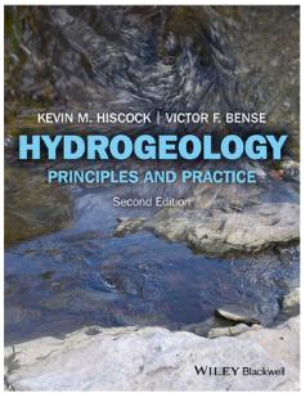
IGI Medal of Honour

EurGeol Kevin Cullen PGeo was the 2015 recipient of the IGI Medal of Honour. The Medal of Honour was awarded at a ceremony held at the offices of the IGI on the 26th May 2015.

Kevin Cullen receiving his Medal of Honour from IGI president Gerry Stanley.

Hydrogeology: Principles and Practice - Second edition published

A second edition of "Hydrogeology: Principles and Practice" *(Kevin Hiscock and Victor Bense)* was published in 2014. It provides a comprehensive introduction to the study of hydrogeology to enable the reader to appreciate the significance of groundwater in meeting current and future water resource challenges. The book presents a systematic approach to understanding groundwater. Earlier chapters explain the fundamental physical and chemical principles of hydrogeology, and later chapters feature groundwater investigation techniques in the context of catchment processes, as well as chapters on groundwater quality and contaminant hydrogeology.



IAH (Irish Group) provide funding for ECHN conference and hydro-holiday

The IAH Irish Group is offering funding for Early Career Hydrogeologists to attend the Early Career Hydrogeologist Network conference in Newcastle (8-9 July 2015) and the hydro-holiday practical field course in Dumfries (6-11 September 2015).

The ECHN conference provides an opportunity for hydrogeologists in the first few years of their career or undertaking a PhD to present their work to their peers via posters and to make valuable contacts at the conference dinner and during the field visit on the second day. The conference, which will be CPD approved, will be hosted by Newcastle University.

For further details see : www.geolsoc.org.uk/HydroG-Early-Career-Conference

The IAH's hydro-Holiday practical field course is being organized by Bob Kalin (2015 Burdon lecturer) and the University of Strathclyde. It will be held in the Dumfries Basin, Scotland. The course will comprise 3 days of hands-on evaluation of aquifer properties (including pumping tests and chemical analyses); as well as lectures by University of Strathclyde and Scottish Water Staff and field trips to sites of hydrogeological interest and groundwater abstraction sites.

For further details see: https://iah.org/knowledge/training/1st-annual-hydro-holiday-practical-field-course

For further details on the funding being offered by the IAH (Irish Group) for these ECHN events please contact Orla O'Connell or Shane Regan at educationandpublicity@iah-ireland.org

Irish Group

IAH (Irish Group) 2014 AGM

Katie Tedd - Secretary

The IAH (Irish Group) AGM was held on 21 October 2014 in the Geological Survey of Ireland.

Owen Naughton was elected as the new conference secretary. Sarah Casey and Les Brown joined the Conference Sub Committee. Many thanks to Colin O'Reilly, Orla McAllister and Caoimhe Hickey, who stepped down from Conference Secretary and Sub committee roles respectively, for their hard work and dedication to the IAH Irish Group.

The IAH members present agreed with the following suggestions made by the committee regarding the IAH's insurance and status:

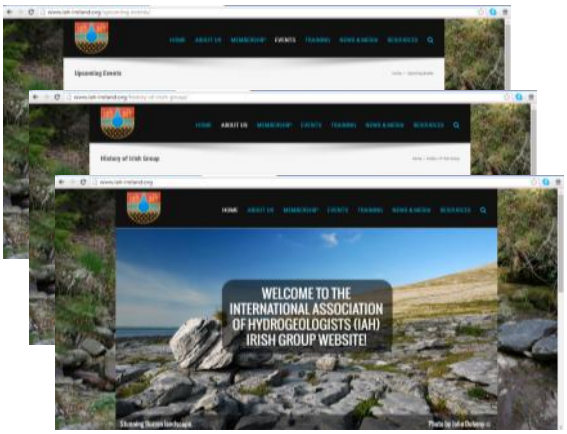
- the IAH should avail of the Public Liability insurance being organised by the Irish Geoscience Network (to cover the liability risk from IAH (Irish Group) events);
- the IAH should apply for charitable status (to exempt the IAH (Irish Group) from most taxes, including DIRT, and to allow us to provide tax clearance certificates for conference participants); and
- the IAH should not become a limited liability company (as annual reporting fees are similar to the funds used for running courses etc.)

The IAH (Irish Group)'s bursary scheme continues to be successful in supporting students studying hydrogeology. The IAH (Irish Group) are grateful to the companies who contribute to this bursary. In 2014, the following companies supported the bursary: ARUP, David Ball, Jones Environmental Laboratories and O'Callaghan Moran.

The deadline for the 2015 Bursary is 10th July 2015. Further details may be found on http://www.iah-ireland.org/bursaries/

IAH (Irish Group) website update

Orla O'Connell and Shane Regan (co-Education and Publicity Secretaries) have been working with Deakin Design to update the IAH (Irish Group) website. This is still a work in progress. Please visit the website: www.iah-ireland.org and contact Orla and Shane with any feedback at educationandpublicity@iah-ireland.org



Screen shots of the updated IAH website: www.iah-ireland.org

IAH (Irish Group) committee 2015

President :	David Drew
Secretary:	Katie Tedd
Treasurer:	Dominica Baird
Conference Secretary	Owen Naugthon
Fieldtrip Secretary:	Aisling Whelan
Education & Publicity Secretaries:	Orla O'Connell Shane Regan
NI Secretary:	Paul Wilson
Burdon Secretary:	Morgan Burke
Conference Sub Committee:	Eleanor Burke John Dillon Roberta Beillini Sarah Casey Les Brown

Irish Group

IAH (Irish Group) 2014 Karst Field Course

Shane Regan — Education and Publicity Secretary

In June 2014 a 2 day field course on karst hydrogeology and geomorphology was hosted by Professor David Drew in The Hydro Hotel, Lisdoonvaranna. It was the second successive year the IAH group facilitated the course and it was re-run due to the original course being oversubscribed and the positive feedback received from those who attended in 2013.

The second delivery of the course proved to be as popular as the first year. The maximum allocation of participant spaces was filled with attendees being drawn from industry, the public service and university. The course consisted of a mixture of lectures from consultants and researchers currently working in karst environments followed by field visits to some of the Burren's most interesting, and indeed aesthetic, geological features.

The IAH Irish Group was delighted to have had presentations delivered by:

- Professsor Laurence Gill (TCD) on numerical modelling methods in karst hydrology;
- John Paul Moore (UCD) on his postgraduate research on karst structural geology;
- Coran Kelly (TOBIN Consulting Engineers) on karst landform characterisation in the River Lee catchment, Co. Cork;
- Henning Moe (CDM) on catchment delineation in karst groundwater bodies in Co. Galway;
- David Ball (consultant) on borehole drilling techniques and problems typically encountered in karstified bedrock; and
- Professor David Drew (retired TCD) on karst hydrology and the integration of the different facets in karst hydrogeological research.

The field visits were led by:

David Drew to a cave system, where David led able enthusiasts through an underground conduit and fracture network, courtesy of hard hats and lamp lights.

Dr Caoimhe Hickey (GSI) to the spring discharges in Toonagh, which included a field based demonstration of flow path determination using florescent tracers.

The course was again a resounding success and the IAH Irish Group committee wish to thank all of the presenters, the attendees for their enthusiastic engagement, and most of all, David Drew for sharing his vast and exciting experiences in karst hydrogeology with his IAH colleagues.

John Paul Moore outlining the importance of structure on karst hydrogeology in the Burren.

Irish Group

IAH (Irish Group) 2014 Annual Fieldtrip

Cork and West Waterford

Aisling Whelan — field trip secretary

The IAH annual field trip took place on the first weekend of October 2014 in the West Waterford/ Cork area. A total of 27 people attended some or all sites visited over the weekend.

The trip kicked off early on a bright and sunny Saturday morning at the Dawn Meats factory site in Kilmacthomas, Waterford. An Integrated Constructed Wetland (ICW) is used to treat industrial effluent generated on the site. The group was guided around the series ICW ponds by Aila Carty of VESI Environmental who talked the group through the design, monitoring and performance of the system. Some of the advantages of ICW systems over more conventional wastewater treatment systems were highlighted including lower set up and operational costs and enhancement of biodiversity. Aisling Whelan of IE Consulting gave an overview of the hydrogeology of the site, including site considerations before the system was designed and proposals to monitor groundwater quality beneath the ICW.

From Waterford the group travelled to Midleton Distillery. After lunch at the visitor centre (which probably wisely did not include any whiskey) the group met up with Donal Hogan of Verde Environmental, Dierdre Larkin of Malone O'Regan and Aidan Curran, environmental manager with Irish Distillers Ltd. Donal provided an overview of the interesting karst hydrogeology of the site which includes a swallow holes and a cavern from which a subterranean stream emerges. A number of production wells were developed at the site in recent years to supply water for process, cooling and potable water needs. The Dungourney River flows adjacent the site and flow monitoring was undertaken prior and subsequent to the commencement of groundwater abstraction and is still ongoing. While groundwater is an important resource for the site, it also presented challenges during construction of an underground tank where pumping of significant groundwater inflows was required to keep workings dry. Aidan is involved in the day to day management of the production wells and talked us through the technical aspects of the operation, treatment and monitoring systems. And finally Deirdre described the groundwater mass balance model she prepared for the catchment area to the site as part of her MSc thesis. Despite there being more of interest to see and hear about at the distillery there was tight schedule to follow and the group left Midleton and made their way into Cork City for the final part of the day's trip.

Aila Carty at Dawn Meats, Kilmacthomas

Dr. Allistair Allen, Paul Sikora and Kevin O'Regan led the final part of the field trip which explored the shallow hydrogeothermal resources of the buried gravel valleys which extend east-west beneath Cork City. Alistair described how due to the heat island effect groundwater in these shallow aquifers is 2-3°C higher than the average 9-11°C for Irish groundwater. We visited two buildings on the UCC campus that utilise open loop systems for space heating and cooling purposes. We started at the Western Gateway Building and then moved the short distance to the beautiful Lewis Glucksman Gallery. Groundwater temperature in the first trial well drilled in the gravels for the Western Gateway

Building was a surprising 19°C. Apparently groundwater temperature varies with air temperature and ranges from 8-19°C annually. We visited the boiler rooms of both buildings and Paul talked us through the design and operation of the systems and it was clear that there are a number of benefits to be gained from utilising geothermal systems like these. While the initial capital costs were higher than for conventional heating systems, running costs are lower. The payback time for the Glucksman Gallery system was originally estimated at 14-15 years, but proved to be only three years. Alistair also pointed out some difficulties with open loops systems in urban areas where there can be issues where poor quality water that is abstracted cannot be re-injected due to restrictions under the Water Framework Directive.

After a long day of travelling for most the group made their way over the River Lee to the Ambassador Hotel where we had a very enjoyable group meal and overnight stay.

The trip continued on Sunday morning to north Cork where Coran Kelly and David Drew introduced the group to the mysteries of the workings of groundwater in the fluviokarst of the Awbeg River Valley. A number of large springs occur along the river and our first stop of the day was Shanballymore Spring, used as a water supply by Cork Co. Co. The spring is located in the valley floor in the interface between the karst (plateau) and fluvio (river) environments. David described how spring hydrographs and hydrochemistry show that the spring doesn't behave like a true karst spring but nor does it display the behaviour of a typical sand and gravel spring, being somewhere in between the two types. It was clear the groundwater flow system in this part of Cork was not straightforward.

Our second stop was a swallow hole at Polleagh where dye had been injected as part of tracer tests undertaken to establish the zone of contribution to Shanballymore Spring. Coran described how negative tracing results to any of the springs provided another clue that the groundwater flow system here is complex. The group also got to see a newly opened sluggera within a farmyard close to

Polleagh Swallow Hole

the swallow hole at Polleagh. Farmers report that these features are common in the area.

The final stop of the morning was to the Bregoge stream which is a tributary of the Awbeg River. The stream sinks in a number of places and from Bregoge Bridge the group walked an interesting 2 km upstream along the dry stream bed to the location of the main sink. Along the way solutionally enlarged features could be seen on outcrop along stream bed. Coran described how there appears to be two groundwater flow systems in operation in the area: a shallow conduit groundwater flow system and a deeper diffuse groundwater flow system. It is thought that the springs are an overflow from the main deeper regional groundwater flow system. Although we didn't get to access it, the nearby well-known Mammoth Cave has been extensively mapped and is thought to be a remnant of an ancient karst landscape in the area. We came away realising there is more interesting work is to be done to understand the complex groundwater flow system in the "Krazy Kork Karst".

The group finished up an enjoyable weekend with lunch at the Firhouse Hotel outside Mitchelstown, before making the journey home.

The field trip guide will be downloadable shortly from the newly redesigned IAH (Irish Group) website at http://www.iah-ireland.org/annual-field-trip/

IAH (Irish Group) 2015 Annual Conference:

Integrated Hydrogeology: Contemporary Principles, Policy and Practice

Owen Naughton — Conference secretary

The 35th annual IAH conference was held on the 21st and 22nd April 2015 in Tullamore, Co. Offaly. The conference theme this year was 'Integrated hydrogeology: Contemporary principles, policy and practice' and was well attended by over 140 delegates and a dozen industry exhibitors. The two-day event saw a host of esteemed Irish and international speakers presenting on various technical, legal and regulatory topics relevant to today's hydrogeological practitioner.

This year events got off to an early start with a special borehole logging field demonstration on Monday afternoon held on the grounds of Carton House, Co. Kildare kindly hosted by RudenAS GeoSolutions and Apex Geoservices and facilitated by the EPA. Fridtjov Ruden and Balazs Rigler (RudenAS) demonstrated a range of borehole logging techniques on the poorly-productive Ryewater borehole, with the results and interpretation presented during the technical workshop on Wednesday afternoon.

On Tuesday, IAH (Irish Group) President David Drew opened proceedings with an introduction and welcome address. David chaired the opening session on 'Hydrogeology in Context' and began by introducing the first of two keynote speakers. Firstly, Denis Peach, visiting Professor at Imperial College London and former Chief Scientist of the British Geological Survey. Prof. Peach's broad-ranging talk described the need for a whole system approach to the subsurface if the future challenges facing hydrogeology are to be met. Our second keynote address was delivered by David Kreamer, Professor at the University of Nevada and the International Association of Hydrogeologists Vice President for North America. Prof. Kreamer gave a stimulating talk illustrating the factors that can hinder efforts to enhance water quality and quantity, sanitation and hygiene (WASH), collectively known as hydrophilanthropy, around the globe.

In the second session Angela Ryan (Irish Water) gave an informative overview of the challenges faced in providing an effective national water supply. An invitation was also extended to the hydrogeological community to engage with Irish Water on the National Water Resources Plan to ensure the future of groundwater in the public supply. Margaret Keegan (EPA) highlighted the effectiveness of communication strategies in managing poor private well drinking water quality, while Pól O'Seasnain (EPA) closed the session with a practical overview on compliance reporting for the Groundwater Regulations 2010.

After lunch Owen McIntyre (UCC) provided expert insights into the legal protection afforded to ecologically significant groundwaters by EU Law. Dr. McIntyre clarified key concepts such as ecological integrity, appropriate assessment and the profound implications of the recent ruling on the proposed Galway bypass by the Court of Justice of the European Union (CJEU). Paul Johnston followed this up with an insightful talk describing the technical concepts of hydrological damage and resilience as it applies to groundwater dependent ecosystems, highlighting the importance of field data in understanding wetland hydrology. The session closed with talks on two major national capacity-building projects; the National Catchment Flood Risk Assessment and Management (CFRAM) and the Irish Soil Information System. Mark Adamson, head of the Flood Relief and Risk Management Division within the OPW, summarised the flood risk management methodologies and outputs from the first implementation cycle of the CFRAM programme and how it relates to groundwater flooding. Iolanda Simo of Teagasc closed the session with

an overview of the extensive predictive soil mapping and ground-truthing methods used to produce a harmonised 1:250000 soil map and information system for Ireland.

The final session on Tuesday comprised the first dedicated Early Career Hydrogeologists' Network session at the annual IAH (Irish Group) conference. Gillian Hurding, co-chair of the ECHN, opened the session by detailing the role early career hydrogeologists can play as groundwater advocates. Gillian was followed by talks on different aspects of hydrogeological research given by early career researchers John Paul Moore, Sara Vero, Hugh Cushnan and Eoin McAleer. The ECHN session was well-received by delegates and will hopefully become a regular feature of the IAH conference in years to come. At the end of a hard day, weary delegates were treated to an evening of whiskey tasting and meal as part of a tour at the redeveloped Tullamore Dew Distillery.

Wednesday opened with Prof. John Walsh (UCD) describing the Irish Centre for Research in Applied Geosciences (iCRAG), a major new research investment by SFI and industry aimed at embedding outcomes of high quality research within industry practice in Ireland. Jean Wilson from Trinity College Dublin presented recent research on the use of remote sensing, GIS and natural tracers to evaluate groundwater discharge to lakes. Jonathan Vouillamoz from the Swiss Institute for Speleology and Karst Studies explained the KARSYS hydrogeological modelling approach which is currently being implemented on test Irish catchments as part of a joint IRC-GSI research fellowship.

The final session consisted of three talks that considered different aspects of geophysical investigation methods and applications. Fridtjov Ruden of RudenAS, Norway, presented on the integration of oilfield geophysics in the quest for coastal mega aquifers on the passive margins of Africa, a pertinent issue in the development of groundwater resources in the region. Peter O'Connor and Shane O'Rourke (Apex Geoservices) followed with a thorough overview of recent surface geophysical surveying techniques relevant to groundwater exploration and protection. To round off the closing session Rachel Cassidy (AFBI, formerly Queens University Belfast) presented recently published work on the application of multi-scale geophysical techniques in the hydro-structural characterisation of catchments.

Balazs Rigler (RudenAS) explains details to David Ball at the Technical workshop on Wednesday afternoon.

The conference finished up on Wednesday afternoon with the technical workshop, wherein Balazs Rigler (RudenAS) and Shane O'Rourke (Apex Geoservices) presented borehole geophysics and electrical resistivity tomography (ERT) investigation results collected during the Monday fieldtrip. The workshop provided an informal and interactive environment where delegates learned a wide variety of geophysical field techniques and brought their own experiences to the debate. A special thanks to RudenAS and Apex Geoservices in particular for their contribution to this year's programme.

The annual conference plays a vital role in funding the activities of the IAH Irish Group throughout the year. On behalf of organising committee Roberta Bellini, Les Brown, Eleanor Burke, Sarah Casey and John Dillon, I would like to thank all delegates, speakers and exhibitors for their support and hope this will continue in the coming years.

GeoGrey – the Burdon Network Grey Literature Database

Morgan Burke—Burdon Secretary

Members of IAH have recognised for some time that there are many reports and pieces of useful literature held by its members and others in paper, or non-digital form. Known as 'grey literature', such information is neither widely known nor easily accessible.

Groundwater specialists and organisations in the developed countries who have worked in developing countries have access to a wealth of grey literature in the form of reports, field notes, appendices of raw data, maps and satellite images. Much of this information is held by individuals and is not restricted, but nor is it fully published. Some literature may be available from institutional or on-line libraries. In some cases the hydrogeologists holding the literature are close to, or beyond, retirement age. There is an obvious danger that the information could be lost.

This grey literature may not be available to the people who most need it. It can, for example, be of benefit to local hydrogeologists and other water specialists working in developing countries including Non Government Organisations (NGOs) and Aid agencies. To address this issue IAH's Burdon Network has developed a system called GeoGrey.

About GeoGrey

GeoGrey is essentially a hub for making connections and facilitating support. It uses a simple, informal system that is indexed by geographical region, allowing someone holding grey literature to mark the outline of the study area on a map, provide a brief description of the title and contents and give contact details – effectively working as a 'click on a map' database for use by those who need it.

It is not intended to be a large corporate database in which the actual documents are stored, rather the purpose is to provide people with an opportunity to record their information and for others to become aware of the existence of this work. Contact details also provide an opportunity for the person requiring the information to make contact with the person who may have worked in the area of interest, even if 30 or 40 years ago. If there appears to be a large demand for a particular document or map, this may inspire the holder of the document to convert it to a digital format for ease of distribution.

GeoGrey is a non-commercial facility and is provided in the hope that it will be helpful to scientists and engineers involved in hydrogeology throughout the world. The initial focus will be on grey literature in areas of sub-Saharan Africa, however entries are not limited to this region and we hope that you will take the opportunity to widen its scope over time.

Participate now

GeoGrey is a new system and needs your help and input to enable it to become a valuable resource for everyone working in the groundwater community. At this initial stage we need to build up meaningful entries from the holders of grey literature in the system, ready to advertise GeoGrey more widely in the future to organisations and communities keen to use the information.

The system is very simple to use and a user guide is provided. Help is also available should any difficulties be encountered.

Find out more:

http://www.geogrey.info/GeoGrey/

IAH: News on the international front

Bruce Misstear—Vice President Finance & Membership, IAH

This is the first of what I hope will be regular updates on IAH international activities in this newsletter.

For this edition, I propose to talk about three items:

- the forthcoming IAH congress,
- the Early Career Hydrogeologists Network ,
- our Education Working Group.

IAH congress, Rome, 13th to 18th Sept 2015

Preparations are well underway for this year's IAH congress, which will be held in Rome. The theme of the congress is "Hydrogeology: back to the future", combining previous experience with future tools and needs. There has been a very high level of interest already in the congress, with over 900 abstracts received.

The congress will be held in the main university in Rome, La Sapienza. The campus is within the ancient city walls, about 10 minutes' walk from the main Termini railway station. The university has excellent facilities, including a main hall (Aula Magna) with seating for 900 participants, suitable for the opening ceremony and plenary sessions, and smaller lecture rooms within the nearby departments of Geology and Mineralogy for the parallel sessions.

The technical programme is shaping up nicely. IAH's Commissions and Networks are participating by convening sessions. There are also a number of interesting pre-congress courses, including courses on contaminant behaviour; model calibration, uncertainty and decision-making; FREEWAT (open source software); aquitard hydrogeology; and solute and reactive transport modelling.

There is a wide range of options for the mid-week excursions, including visits to ancient hydraulic structures, karst aquifers, major springs and volcanic aquifers. There is also the option of an audience with the Pope. Post-congress tour options take in Tuscany, the Apennines, the Venetian lagoon, the western Italian alps, the volcanics around Naples and the karst aquifers of Puglia in the heel of Italy.

The main university building at La Sapienza containing the Aula Magna

The Aula Magna, with seating for up to 900 delegates

One of the lecture theatres inside the Geology department.

Two model dinosaurs outside the building containing the Geology and Mineralogy departments

It would be good to see a large Irish involvement in the congress. For those of you who haven't attended previous congresses, it's a great way to keep abreast of what's happening internationally. And the social side is very enjoyable too. Details of the congress are available at www.iah2015.org.

Early Career Hydrogeologists Network

The ECHN was established in 2011 as part of the Association's Forward Look strategy. It is primarily aimed at hydrogeologists who are within the first decade of their career, and provides opportunities for networking, training, mentoring, etc. The network has an excellent website: https://echn.iah.org/ and there is an active discussion forum on LinkedIn. Some of you will have heard Gillian Hurding from the UK branch of ECHN talk about the network at the recent IAH (Irish Group) conference in Tullamore. As I said then, I would urge early career hydrogeologists in Ireland to get involved.

The ECHN will be participating again at this year's IAH congress, with both a training event and an evening social. Last year, the social event included a team exercise prepared by Hydrogeologists Without Borders (the team I joined didn't do so well, perhaps because I had worked in the country where the problem was set). There will also be a Coolest Paper award to an ECHN member at the congress.

The Education Working Group

One of the tasks I have been involved in since becoming a VP of the Association is to chair a working group on education. Many of the core activities of a professional association are directed towards the education and academic development of its members, the broader groundwater community and the general public. For IAH, this has historically included our congresses, books and journal publications and the work of our commissions, together with the events and activities of our national chapters. The Forward Look plan provided an opportunity to review IAH's educational activities, and the new IAH website gives us a platform to develop some of these in new ways.

The working group was set up in 2013. Since then, the group's activities have included a survey of on-line training resources (webinars) and web-based educational materials, and an on-line survey seeking our members' views (in April 2014). A report on the group's work was presented to IAH Council in Marrakech in September last year, with the following

recommendations:

- creating a separate "Education and Training" banner on the IAH website home page;
- preparing a list of hydrogeology degree courses available around the world, with links to course information from the IAH website;
- listing short courses, field courses and webinars organised by national chapters;
- developing an IAH YouTube (or similar) channel;
- linking with existing webinar providers to produce IAH-branded talks;
- compiling an international panel of experts willing to give their time to contribute to short courses organised by national chapters;
- preparing IAH-branded educational materials;
- developing a series of short thematic papers on key strategic topics to increase awareness of groundwater issues.

The working group is now engaged on implementing these recommendations, with an initial focus on adapting our webpages. There is a new training page on the website and further pages will be added in the coming months that will provide links to educational materials, as well as giving more information on short courses, webinars and degree programmes. We will also be seeking volunteers who are willing to offer their expertise to assist with short courses organized and run by national chapters. If you have suggestions for educational activities please let us know.

And finally…….

For more information on IAH activities go to the main IAH website at https://iah.org/. This includes details of how to join the Association. The full annual membership fee is €80 if you wish to receive a paper copy of Hydrogeology Journal as part of your membership, or €70 if you receive the journal online. Students can join for as little as €19 (with the online journal option).

Leading lights of the Early Career Hydrogeologists Network relaxing at their AGM in Perth, in 2013. The current chair, Vivian Re (Italy) is second from the left, with co-chair Gillian Hurding on the right.

IAH President Ken Howard (Canada) presents the ECH-N's "Coolest paper" award to Sebnem Arslan (Turkey), at the IAH congress Marrakech in 2014.

Previous issues available at

www.gsi.ie

The contributors are responsible for the content of the material in this Newsletter. The views expressed are not necessarily those of the Geological Survey of Ireland.

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Upcoming Events

2015

From Jul 2015	**Engineer's Ireland CPD professional training** - Clyde Road 50% off summer special http://www.engineersireland.ie/CPD-Training.aspx
8-9 July 2015	**IAH Early Career Hydrogeologist Network's Conference** - Newcastle University http://www.geolsoc.org.uk/HydroG-Early-Career-Conference
26-27 July 2015	**Open University Geological Society Field Trip** - North Antrim Coast Email: ireland@ougs.org
28 Aug 2015	**Irish Mining and Quarrying Association Field Trip** - Lisheen Mine http://www.igi.ie/news/imqs-field-trip-to-lisheen-mine.htm
29-30 Aug 2015	**Open University Geological Society Field Trip** - Connemara Email: ireland@ougs.org
From Sept 2015	**IAH (Irish Group) Technical Discussion Meetings** (TDMs) - GSI TDMs are held on the first Tuesday of the month between Sept and May in the GSI http://www.iah-ireland.org/upcoming-events/
13-18 Sept 2015	**42nd IAH Congress** - Rome, Italy http://www.iah2015.org/
21-23 Sept 2015	**EcoHydrology 2015** - Lyon, France http://ecohydrologie.sciencesconf.org/
21-24 Sept 2015	**Land Use and Water Quality LuWQ2015** - Vienna, Austria http://web.natur.cuni.cz/luwq2015/
25-29 Sept 2015	**Irish Quaternary Association Field Meeting** - South Coast http://www.iqua.ie/field_meetings.html
6-11 Sept 2015	**1st Annual Hydro-Holiday Practical Field Course** - Glasgow and Dumfries, Scotland https://iah.org/knowledge/training/1st-annual-hydro-holiday-practical-field-course
28-30 Sept 2015	**Catchment Science 2015** - Wexford http://www.teagasc.ie/agcatchments/catchmentscience2015.asp
TBC Oct 2015	**IAH (Irish Group) Annual Fieldtrip** - Kilkenny / Wexford Contact Aisling Whelan: fieldtrip@iah-ireland.org
TBC Oct 2015	**IAH (Irish Group) AGM** - GSI Contact Katie Tedd: secretary@iah-ireland.org
TBC Oct 2015	**IAH (Irish Group) "Hydrology for Hydrogeologists" course** - GSI Contact Shane Regan: educationandpublicity@iah-ireland.org
14-15 Oct 2015	**2nd IAH Central European Groundwater Conference** - Constanta, Romania http://www.ahgr.ro/en/events.aspx
14 Nov 2015	**Open University Geological Society Visit** - DIAS Email: ireland@ougs.org

2016

21 Feb 2016	**Open University Geological Society Field Trip** - Enfield Thermal Springs Email: ireland@ougs.org
TBC May 2016	**Groundwater in Fractured Bedrock Environments** - Queen's University Belfast Email: u.ofterdinger@qub.ac.uk

If you are involved in an event which you would like to be advertised in the groundwater newsletter please email details to groundwaternewsletter@gsi.ie

The editors welcome feedback on the contents of this issue and the changes to the newsletter, as well as suggestions for contributions to the next issue. Please contact: Groundwaternewsletter@gsi.ie

Contributions for the next issue should arrive before 29 Jan 2016.