INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS
(IRISH GROUP)

presents

GROUNDWATER & THE LAW: DIRECTIVES, STANDARDS, & REGULATIONS

PROCEEDINGS

OF THE

20th ANNUAL GROUNDWATER SEMINAR

VENUE:

KILLESHIN HOTEL, PORTLAOISE

DATES:

TUESDAY, 11th & WEDNESDAY, 12th APRIL, 2000

2000 IAH (IRISH GROUP) PORTLAOISE SEMINAR ORGANISING COMMITTEE:

Geoff Wright, President; Geological Survey of Ireland
Anita Furey, Secretary; K.T.Cullen & Co. Ltd.
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Whilst available, copies of these Proceedings can be purchased for £15 (plus postage £2) by application to the 2000 IAH (Irish Group) Portlaoise Seminar Secretary.

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INTRODUCTION & FOREWORD

The International Association of Hydrogeologists (IAH) was founded in 1956 to promote co-operation amongst hydrogeologists, to advance the science of hydrogeology world wide, and to facilitate the international exchange of information on groundwater. The IAH is a worldwide scientific and educational organisation with more than 3,000 members in over 120 countries.

The Irish Group of the IAH started in 1976 and now has ca. 60 members. It hosts the annual groundwater seminar in Portlaoise and holds technical discussion meetings on the first Tuesday of every month between October and June in the Geological Survey of Ireland offices in Dublin.

The following members are serving on the 2000 IAH (Irish Group) committee:

- President: Geoff Wright ☎(01) 670 7444
- Secretary: Anita Furey ☎(01) 294 1717
- Treasurer: Margaret Keegan ☎(053) 47120
- Portlaoise Secretary: Shane Bennet ☎/📠(045) 864795
- Fieldtrip Secretary: Morgan Burke ☎(01) 296 4435

The IAH Irish Group welcomes the delegates and speakers to this year's seminar and encourages all to participate fully in the formal and informal discussions over the two days.

Shane Bennet,
Seminar Secretary, IAH Irish Group 2000

Seminar Objective

The objective is to provide a forum for the presentation and discussion of papers relevant to the topic of *Groundwater & the Law*. This two-day seminar is divided into five sessions. Emphasis will be placed on relevant directives, standards, and regulations. Experts in these fields have generously volunteered to give of their time and all those involved with groundwater or its legal interpretation are urged to attend this important annual seminar.

The Speakers

In the following section we introduce the speakers and their topics. In some cases limited information was available at the time of going to print and consequently we apologise to delegates and speakers for any omissions.

James Hunt is a Senior Scientist with the UK Environment Agency and our keynote speaker this year. He is Chief Technical Adviser to the Agency for new European and International Commitments. In his presentation James will discuss the EU Water Framework Directive and its implications for groundwater.

David Moore has been with the DoELG for 22 years and deals with water pollution: legislation and policy both national and international. He was formerly 4 years with Dublin CC water treatment plant in Leixlip and previous to that spent 5 years in Canada working in an uranium and copper mine. In his presentation David will discuss the impact of the EU Framework Water Directive for Ireland.

Vincent Fitzsimons graduated with a degree in Earth Science from TCD. (1st Class Hons with scholarship) and an MSc in Hydrogeology from Birmingham. He worked for 2 years in geotechnical and hydrogeological site investigation for landfill with Bernard Murphy & Associates and subsequently spent 3.5 years on hydrogeological investigation and remediation of contaminated land sites with Dames & Moore. He has now been with the groundwater section in the Geological Survey of Ireland for 1.5 years and is involved with groundwater protection - policies and implementation. Vincent's paper deals with the implementation of the Nitrates Directive.

Ken Howard is Professor of Hydrogeology at the University of Toronto and director of the Groundwater research Group. He graduated with an M.Sc. from the University of Birmingham in 1975 and subsequently a Ph.D. in 1979). He is certified by the American Institute of Hydrology and Chartered by the British Geological Society and holds the Chair of the International Association of Hydrogeologists Commission on Groundwater in Urban Areas (IAHCGUA). His research interests include all aspects of groundwater resource evaluation, management and protection. Ken will be presenting a Canadian perspective on groundwater jurisdiction.

Padraig Thornton is an inspector with An Bord Pleanala. In his paper Padraig will be giving us the benefit of his experience with groundwater and planning issues.

Fergus Coyle is a Senior Executive Engineer with Monaghan County Council. In his paper Fergus discusses property acquisition as a vehicle currently available to local authorities in connection with groundwater supply and planning issues.

Kevin Cullen is a member of the recently formed Institute of Geologists of Ireland and Managing Director of K.T. Cullen & Company Limited. He has over 30 years of experience in Irish geological environments and specialises in groundwater development and catchment management studies. He has appeared as an expert witness in the Irish Courts and at Bord Pleanala hearings for projects covering a multitude of groundwater related issues including landfilling, quarrying and flooding. In his presentation Kevin gives us the benefit of some of these experiences.

David Ball is a graduate of Trinity College Dublin and London University and has worked for 29 years as a consultant hydrogeologist in Ireland, Europe, Africa, Arabia, and Asia. He is currently working as a consultant for various state and local authority bodies on planning matters and groundwater development. David's paper draws upon his extensive experience of drilling in these areas and campaigns for standards in well construction.

Kalpana Unadkat is a senior solicitor with Ashurst Morris Crisp, a London law firm. She is admitted as a solicitor in England & Wales as well as India. She joined Ashurst's Project group in 1998 after five years with leading Bombay firms where she developed knowledge of the legal risks and practical features of investing in India. She has advised clients on approvals and clearances required from various Central Government/State Government/Local Authorities for setting up projects in India. Her experience of the Indian investment market extends to in-depth understanding of Indian business, addressing commercial and business issues and the necessary approvals and clearances (including environmental) required to set-up projects in India. Kalpana has worked on major transactions while advising multinationals like Shell, BP, Powergen, Soros Find Management and Unocal Corporation. She has written various articles including Power Liberalisation in India for International Energy Law and Taxation Review, the Indian Run-up to the Millenium for Asian Legal Briefing, Acquisition of listed companies in India for Business Eye and Insurance reforms in India for Internationales Steuerrecht.Kalpana's paper presents an overview of groundwater law in India with particular reference to abstraction rights and licensing.

Johannes Lijzen graduated at Wageningen Agricultural University in Environmental Sciences in 1990. Since 1992 he has been working at the National Institute of Public Health and the Environment (RIVM) on projects concerning environmental technology and soil protection. From 1997 onwards he is working at the Laboratory of Soil and Groundwater research of the RIVM on projects focussing on risk assessment of soil contamination, among which the evaluation of soil and groundwater quality guidelines and remediation objectives. His joint paper with Frank Swartjes describes the derivation and application of the Dutch Groundwater Quality Guidelines.

Lutz Haamann has been employed as a geologist with the Corporate Environmental Department of the chemical company Degussa-Hüls in Frankfurt since 1990. His main involvement is with site remediation and assessment. In 1986 he graduated with an MS (Diplom) in Geology from the Institute for Sedimentary Research at the University of Heidelberg. His MS concerned heavy metals in forest soils. Between 1986 –1990 he undertook a Ph.D. at the Institute for Environmental Geochemistry , University of Heidelberg, on the behaviour of Chromium in contaminated soils. Lutz is a member of working groups in the Association of Chemical Industry of Germany (VCI), the Association of German Industry (BDI), and in International Standards Organisation technical committee 207 Subcomittee 4 on Environmental Site Assessment. His paper presents the German groundwater quality standards.

Barry Smith graduated with a PhD in geochemistry and is Manager of Pollution, Waste and Mine Impact with the British Geological Survey. Barry's paper discusses the development of soil and groundwater quality standards for contaminated land in the United Kingdom.

Margaret Keegan graduated from UCG with a BSc (Hons) in geology and from Sligo RTC with an MSc in Environmental Geology (Hydrogeology) by research. She worked for the Geological Survey of Ireland and subsequently for an environmental consultancy specialising in waste management. Margaret joined the Environmental Protection Agency in 1997 in the capacity of Waste Licensing Inspector. Other areas of specialisation include groundwater protection, contaminated land, and integrated surface water and groundwater planning. Her joint paper presents the "Development of Guideline & Intervention Values for the Protection of Groundwaters in Ireland".

Gerard O'Leary graduated from University College Cork with a Bachelors degree in Analytical Chemistry and from Trinity College Dublin with a Masters degree in Environmental Science. He worked for Tipperary South Riding County Council for 10 years before joining the Environmental Protection Agency in 1994. Ger is a member of the Institute of Chemistry and his joint paper presents the "Development of Guideline & Intervention Values for the Protection of Groundwaters in Ireland".

Eugene Daly graduated from UCD with a BSc (Hons) in 1968 and from North Carolina State University in 1971 with an MS. He worked for the Geological Survey of Ireland Groundwater Section for ca. 20 years and has operated his own groundwater consultancy EDA & Associates since 1994. Eugene presents a consultant's perspective of Groundwater & the Law.

Yvonne Scannell is Professor and lecturer in environmental law at Trinity College and a consultant to the law firm of Arthur Cox & Associates. She is the author of "Environmental & Planning Law and in her presentation she gives an environmental perspective of groundwater and the law in Ireland.

Peter Bennett graduated from Queens University Belfast in 1964 and subsequently worked for the British Geological Survey. Peter is Managing Director of Hydrogeological & Environmental Services Ltd., a Chartered Geologist and one of the most experienced hydrogeologists in Ireland. In his paper Peter discusses the development of the relationship between groundwater and law from a historical perspective.

1. *Keynote Lecture:* EU Water Framework Directive

James Hunt, UK Environment Agency

THE PROPOSAL FOR A COUNCIL DIRECTIVE ESTABLISHING A FRAMEWORK FOR COMMUNITY ACTION IN THE FIELD OF WATER POLICY

THE WATER FRAMEWORK DIRECTIVE

James Hunt, The Environment Agency for England and Wales

ABSTRACT

The Water Framework Directive, which was originally proposed by the European Commission in February 1997, is currently in the final stage of negotiations, and is expected to be finalised in the summer of 2000. Therefore the text upon which this paper is based may be subject to significant change.

The Directive is intended to replace many pieces of the existing water quality legislation, including the Groundwater Directive (80/68/EEC), and to provide a comprehensive system of environmental protection for surface waters and groundwater. As such it is both ambitious and radical, and its potential impact should not be underestimated.

The stated purpose of the Directive is to "protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems." The main objectives to be met in fulfilment of this purpose are threefold for groundwater:

Good groundwater chemical status
Good groundwater quantitative status
Trend reversal

Good groundwater chemical status is defined as the achievement of existing environmental quality standards, the absence of saline intrusion and a chemical condition which does not compromise the achievement of the objectives set for associated surface waters.
Good groundwater quantitative status is defined as being achieved when the rate of abstraction does not exceed the "available groundwater resource". In this context "available" must take account of the water needs of associated surface water ecosystems.
The trend reversal provisions require Member States to take steps to reverse any significant and sustained upward trend in the concentration of any pollutant.

Additional objectives are also specified for specific cases, such as bodies used for the abstraction of drinking water, and a number of derogation provisions are provided to accommodate instances when the objectives are unachievable as a result of economic, technical or natural constraints.

The objectives are to be achieved through the application of three "programmes of measures" each of six years duration. These programmes are to be drawn up and effected using the practice of River Basin Management Planning. The measures included within these programmes will include regulatory, economic, remedial and voluntary components.

THE ORIGINS OF THE DIRECTIVE

European legislation in the field of water quality has been in existence for over 25 years. In this time there have been numerous instruments introduced including Directives on Surface Water Abstraction, Bathing Water, Dangerous Substances, Freshwaters, Shellfish Waters, Groundwater, Nitrates, and Urban Wastewater Treatment. However this body of legislation does not form a coherent whole. In view of this there has been a growing body of opinion within the European institutions that water quality should be addressed by a "framework" Directive to parallel those that exist already for waste and air.

There has been much criticism levelled at the Water Framework Directive both as a Commission proposal and more recently as Council Common Position. Whilst some of this criticism is undoubtedly valid, two points should be borne in mind:

- The European legislative process requires, by its very nature, compromise both on the part of the Member States and the European institutions; and

- That the Directive is extremely ambitious:

    - It applies to all waters (including 1 mile of coastal waters) rather than leaving the scope of application to be determined by Member State designations;
    - It adopts the River Basin Management approach to planning and implementation;
    - It attempts to link surface water and groundwater both quantitatively and qualitatively;
    - It judges surface water quality on the basis of ecological characteristics; and
    - It attempts to address charging for water.

The Commission originally proposed the Directive in February 1997. The European Parliament's initial reaction to the proposal was to call for the inclusion of:

- provisions to deal with dangerous substances and so replace the Dangerous Substances Directive;
- further detail on the definition of good status for both surface water and groundwater; and
- further detail on the monitoring and assessment requirements;

before it would deal with the proposal any further.

The Commission responded by augmenting the original proposal, firstly in November 1997, with a proposal to replace the Dangerous Substances Directive 76/464/EEC, and again in February 1998 with detailed definitions of the quality objectives under the Directive. These latter were developed in parallel with the European Council Expert Working Group.

Council Working Groups then engaged in intensive negotiations to amend the Commission proposal during the first half of 1998, which led to a preliminary political agreement in the Environment Council in June1998. The European Parliament carried out its first reading in February 1999, and the Council responded quickly by reaching a political agreement on a "common position" in March 1999. However the legislative procedure for the Directive changed on the 1st May with the entry into force of the Amsterdam Treaty, and parliamentary elections, which took place in June 1999, also delayed negotiations. The European Parliament concluded its second reading in February 2000, in which it proposed a large number of amendments to the Council Common Position. Informal conciliation negotiations are currently taking place between the Council and the Parliament, and formal negotiations are expected to start in May and conclude by the end of June. During the course of these negotiations it is envisaged that the Council will accept a number of amendments to the text in respect of groundwater. Therefore it should be borne in mind when reading this paper that the Council Common Position text, on which the following commentary is based, is liable to change.

THE PURPOSE OF THE DIRECTIVE

The purpose of the Directive, as described in the preamble and Article 1, imposes no directly binding obligations upon Member States. However the detailed provisions of the Directive should be judged in the light of the purpose. Article 1 states:

> *The overall purpose of this Directive is to establish a framework for the protection of inland surface water, transitional waters, coastal waters and groundwater which:*
>
> - *prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;*
> - *promotes sustainable water use based on a long-term protection of available water resources;*
> - *contributes to mitigating the effects of floods and droughts*
>
> *and thereby contributes to:*
>
> – *the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use;*
>
> – *the protection of territorial and marine waters;*
>
> – *achieving the objectives of relevant international agreements including those which aim to prevent and eliminate pollution of the marine environment; and*
>
> – *the progressive reduction of emissions of hazardous substances.*

As noted above, the purpose of the Directive is very ambitious. However two points of detail should be noted in respect of groundwater.

Firstly, no direct reference is made to groundwater quality for its own sake, but rather it is considered as part of the quality of aquatic ecosystems or in respect of the potential utility of groundwater for drinking water. Secondly it could be argued that the wording of this Article reflects the subsidiary status that is afforded to quantitative issues. The Directive is intended to "<u>promote</u> sustainable water use" rather than *require* it, and should "<u>contribute</u> to the provision of the sufficient supply …" rather than *ensure* it. This second point may be considered a reflection of the different legal basis that would apply under the European Treaty to a measure which dealt primarily with water resources.

In order to achieve the purpose set out above, the Directive sets out a series of environmental objectives, which are detailed below. These environmental objectives are to be realised by the adoption of River Basin Management Plans.

ENVIRONMENTAL OBJECTIVES

The objectives of the Directive are specified in Article 4, which states that

> *Member States shall aim to achieve the objectives of:*
>
> *preventing deterioration of groundwater status, restoring bodies of groundwater, and ensuring a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status in all bodies of groundwater, in accordance with the provisions laid down in Annex V, at the latest 16 years after the date referred to in Article 29 and reversing any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity, subject to the application of extensions determined in accordance with paragraph 3 and to the application of paragraphs 4, 5 and 6;*

It should be noted that Member States are required to "aim to achieve" these objectives. Therefore, it will not be an offence under European law to fail to achieve the objectives. It will however be an offence to fail to:

> *"ensure the establishment for each River Basin District ... of a programme of measures ... with the aim of moving progressively towards achieving the objectives established under Article 4."*

as required by Article 11.1. (This point is currently a matter of debate as part of the conciliation process and the wording of Article 4 may be subject to change. This situation can be compared with the provisions of the Bathing Water Directive 76/160/EEC, requires the achievement of environmental standards, and the Urban WasteWater Treatment Directive 91/271/EEC, which requires the adoption of measures).

Article 4 specifies the default objective for all bodies of groundwater as "good status", unless the body is subject to the derogation provisions (Articles 4.3, 4.4, 4.5 and 4.6). It should be noted that this blanket approach differs from that adopted in many previous water quality directives, which have only been applicable to those bodies of water designated by the Member State. This will reduce the impact of inconsistent designation practices that have been apparent between Member States in the implementation of previous Directives. Nevertheless there can be little doubt that the application of the derogation criteria in this Directive will be inconsistent, and so some discrepancies will remain between Member States.

The default objective of "good groundwater status" is defined in Article 2:

> *"Good groundwater status" means the status achieved by a groundwater body when both its quantitative status and its chemical status are at least "good".*

Quantitative Status and Chemical Status are examined below.

GOOD GROUNDWATER CHEMICAL STATUS

"Good groundwater chemical status" is the status defined in table 2.3.2 of Annex V.

Table 2 – Section 2.3.2 of Annex V

Elements	Good status
General	The chemical composition of the groundwater body is such that the concentrations of pollutants: - as specified below, do not exhibit the effects of saline or other intrusions - do not exceed the quality standards applicable under other relevant Community legislation - are not such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body
Conductivity	Changes in conductivity are not indicative of saline or other intrusion into the groundwater body

The definition of good groundwater chemical status is the subject of considerable debate at present. A number of proposals have been made by Parliament, including the possibility of achieving a state of "insignificant anthropogenic pollution" in all groundwater.

The adoption of environmental quality objectives for groundwater will doubtless remain a subject of considerable debate for many years to come, but it appears to the author that there are three different types of approach that can be taken, although there are obviously many variations on these themes:

- Referential definition of quality – by this I mean a definition of status which refers in some way to the natural (ie. Completely unaffected) condition of a groundwater
- Absolute definition of quality – an example of such might be the application of the Drinking Water Directive (98/83/EC) standards to groundwaters
- Pragmatic definition of quality – the environmental objectives are derived separately for each groundwater body with the over-riding proviso that there is no significant and sustained deterioration in groundwater quality. Using such an approach remediation targets would vary from one aquifer to another.

The Council text has adopted a "pragmatic approach" as I have called it, whereas the Parliament is arguing for a fairly stringent referential approach. Suggestions for an absolute approach have been made to both institutions but have not proved popular. Which approach will prevail is a matter of conjecture at present.

GOOD QUANTITATIVE STATUS

According to Article 2:

> *"Quantitative status" is an expression of the degree to which a body of groundwater is affected by direct and indirect abstractions.*

Section 2.1.2 of Annex V, which is reproduced below, augments this very general definition.

Table 3 – Section 2.1.2 of Annex V

Elements	Good status
Groundwater level	The level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction. Accordingly, the level of groundwater is not subject to anthropogenic alterations such as would result in: – failure to achieve the environmental objectives specified under Article 4 for associated surface waters – any significant diminution in the status of such waters – any significant damage to terrestrial ecosystems which depend directly on the groundwater body. and alterations to flow direction resulting from level changes may occur temporarily, or continuously in a spatially limited area, but such reversals do not cause saltwater or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions.

The definition can be summarised in symbolic terms as:

ABSTRACTION # (RECHARGE – ECOLOGICAL FLOW REQUIREMENT)

given the definition of "available groundwater resource":

> *"Available groundwater resource" means the long term annual average rate of overall recharge of the body of groundwater less the long term annual rate of flow required to achieve the ecological quality objectives for associated surface waters specified under Article 4, to avoid any significant diminution in the ecological status of such waters and to avoid any significant damage to associated terrestrial ecosystems.*

This definition of "available groundwater resource" is recapitulated in the tabular definition above through the use of the "accordingly" construction.

Examining this definition more closely it is clear that quantitative status is dependent upon two different criteria:

- No unsustainable exploitation; and
- No detriment to the ecological objectives of surface ecosystems.

Clearly these two criteria are combined in the definition of available groundwater resource, but if one were to consider a circumstance where the ecological requirements term were zero, then there remains a sustainability constraint. This is the only criterion in the Directive that does not equate sustainability with a level of ecological quality, and comprises two considerations:

- Not exceeding the available recharge; and
- Not causing intrusions that might diminish the groundwater quality.

These requirements will entail the capacity to predict for a given groundwater body, the recharge characteristics and the potential for intrusion under a given abstraction regime. Whilst the technical knowledge to undertake management of ground-waters to achieve these objectives is available for many aquifers, it is clearly not available for all, and both basic research and technical development would seem to be required.

It is of note that the detailed phrasing of the requirement is quite specific. "Long term annual average" is intended to reflect the practical ambition of avoiding a statistically significant long-term trend towards unsustainable depletion. It should be noted that the use of this terminology is also subject to debate at present; Parliament have suggested its replacement with "current".

Further technical development will also be necessary to address the second criterion, that of ecological quality, which comprises three aspects:

- No deterioration in surface water quality as a result of abstraction of groundwater;
- No impediment to the achievement of surface water quality objectives as a result of abstraction of groundwater; and
- No detriment to terrestrial ecosystems directly depending on the groundwater; including groundwater-fed wetlands.

Surface water quality is defined in the Directive as comprising:

"chemical quality" which is judged in relation to the achievement of the Environmental Quality Standards for priority list[1] substances

and

"ecological quality" which is defined in terms of biological quality (aquatic flora and fauna) and physico-chemical quality (general conditions and pollutants)

It is conceivable that a reduction in groundwater flow could lead to a "priority list" EQS being exceeded in a surface water as a result of reduced dilution. Whilst it is not envisaged that this will occur often this must be considered when setting discharge consents and abstraction limits.

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[1] The "Priority List" will be a list of toxic persistent and bio-accumulative substances of Community wide concern, drawn up by the Commission and agreed by the Council and the Parliament and will effectively replace List I of the Dangerous Substances Directives

The most prevalent scenario whereby groundwater quantity might have a direct adverse influence on surface water status is in respect of the ecological objectives for surface waters. As noted above these consist of physico-chemical and biological components. The physico-chemical components of quality comprise general conditions such as temperature and oxygenation, and the concentrations of non-priority list pollutants (similar to List II of the Dangerous Substances Directive). Again it is conceivable that groundwater quantity could affect physico-chemical quality, but it is more likely that it will influence biological quality.

The biological quality of fresh waters is defined in the Directive in terms of the populations of aquatic flora, invertebrates and fish. Therefore, in order to define the objectives for groundwater quantity it is necessary to understand the water quantity requirements of these populations in order that they may achieve "good status". This field, hydro-biology or hydro-ecology, has seen many developments in recent years and we have gained a reasonable knowledge of some of the relationships between biota and flow conditions, but there are many aspects of which we have only a limited understanding.

Moreover an understanding of the biological needs is insufficient to define the groundwater objectives, since it is also necessary to understand the influence of an abstraction on the groundwater flow and thence the influence of groundwater flow on the overall surface water flow.

TREND REVERSAL

In the case of surface water quality there are five classes defined, *high, good, moderate, poor* and *bad*. Therefore it has been possible to define "no deterioration" for surface water quality in terms of not slipping down these quality classes. However there are effectively only two classes for groundwater quality and therefore a meaningful definition of "no deterioration" is not possible using the same approach. Therefore an additional clause is included in Article 4 whereby Member States are required to take measures aimed at:

> *... reversing any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity...*

Whilst this provision is generally considered worthwhile, it has been criticised on three main counts:

- It does not specify the date from which trends are to be identified
- It does not specify the level of significance or confidence which should be applied in determining the presence of a trend
- It does not explicitly require the adoption of a proactive or precautionary approach whereby measures are taken to control activities that might lead to such a trend (this point is arguable since the catch-all provision in 11.3.f requires control of activities which "would" prevent achievement of the objectives, and this use of the conditional tense could be considered precautionary)

Consequently this provision is also the subject of debate at present. Parliament have tried to suggest the use of an approach entailing "trigger values".

OBJECTIVE SETTING AND DEROGATIONS

Article 4 also allows a number of derogations to be utilised. These allow the lowering of the objectives and an extension to the time allowed to achieve them, and are summarised in Table 4.

Table 4 – Possible Environmental Objectives

Objective	Target Date	Relevant Article	Comment
Good Status	2015	Article 4.1	Presumed "default" in the absence of any of the circumstances below
Good Status Later	2021,2027, 2033	Article 4.3	Time Extension on grounds of naturally slow rate of improvement, economic or technical considerations
Less than Good	2015	Article 4.4 Annex 2 - § 2.4	Less stringent objective set to protect other human interests, but achievable in default time-scale
Less than Good Later	2021, 2027, 2033	Article 4.4 Annex 2 - § 2.4	Less stringent objective set to protect other human interests, not achievable in default time-scale

The setting of these objectives will be managed by the competent authority appointed by the Member State Government, but will also include the opportunity for input by stakeholders and interested parties, through consultation on the draft river basin management plans. Clearly the key to these deliberations will be the interpretations of the definitions of "good status" as discussed above, and the application of the derogation criteria.

Under the terms of Article 4.3, the target date for the objective may be extended when *"Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the time scale ... "* Extensions may be made by the Member States up to 2028, and a final extension may be made to 2034 with the agreement of the European Commission.

The interpretation of reasonably will be a matter for the Member State. This "test" should be compared with those of "infeasible" and "unreasonably expensive" as utilised in Article 4.4.

Article 4.4 sets out the circumstances under which objectives other than "good" can be adopted.

> *"Member States determine that the body of water is so affected by human activity or its natural condition is such that improvements in status would be infeasible or unreasonably expensive;"*

This derogation provision is given more substance by the provisions of Annex II, which contains Section 2.4:

> *2.4 Review of the Impact of Changes in Groundwater Levels*
>
> *Member states shall also identify those bodies of groundwater for which lower objectives are to be specified under Article 4 including as a result of consideration of the effects of the status of the body on:*

- *surface water and associated terrestrial ecosystems*
- *water regulation, flood protection and land drainage*

- *human development*

In both instances the details of, and the reasons for the derogation shall be published in the relevant River Basin Management Plan.

The criteria, which are to be, applied to the use of these derogations are also the subject of considerable debate at present and may change as a result of the conciliation negotiations. The Parliament are attempting to institute requirements which entail the application of "objective" criteria to the use of the derogations, rather than leaving the matter very much under Member State control.

RIVER BASIN MANAGEMENT PLANNING PROCESS

As indicated above, the objectives of the Directive are to be achieved through a river basin management planning process, which is summarised in Table 1, and described in more detail below.

Table 1 – The River Basin Management Planning Process

Article	Annex		Deadline
23		CREATE LEGAL FRAMEWORK Transpose Directive into National Legislation	2003
5	II	DATA COLLECTION Collect data on environmental factors and human activity which may affect water quality and quantity including hydrogeological data and pollution inventories	2005
5	II	DATA ANALYSIS Analyse the data to determine what actions may be required to achieve the environmental objectives, including vulnerability mapping and risk analysis	2005
4, 11	VI	DEVISE DRAFT RIVER BASIN MANAGEMENT PLAN Propose programme of measures to achieve the objectives and propose use of derogations where applicable	2008
14		CONSULT ON DRAFT RIVER BASIN MANAGEMENT PLAN Undertake two phase public consultation process	2009
13		FINALISE RIVER BASIN MANAGEMENT PLAN Publish final River Basin Management Plan	2010
11		ENACT RIVER BASIN MANAGEMENT PLAN Carry out Programme of measures	2010 – 2013
8	V	MONITOR RESULTS OF PROGRAMME OF MEASURES Undertake Environmental Monitoring to determine efficacy of measures adopted	2007 -
13		REVIEW RIVER BASIN MANAGEMENT PLAN Review River Basin Management Plan in light of monitoring results and implement 2nd (and 3rd) 6 year plans as above	2016

GROUNDWATER CHARACTERISATION

The requirement to collect data and analyse it, as referred to in the above table, is termed characterisation. The detailed specification for this is contained in Annex II, which allows for at least two levels of characterisation:

> *2.1 Initial Characterisation*
>
> *Member states shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member states may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify :*
>
> *the location and boundaries of the groundwater body or bodies*
>
> *the pressures to which the groundwater body or bodies are liable to be subject including:*
>
> - *diffuse sources of pollution*
> - *point sources of pollution*
> - *abstraction*
> - *artificial recharge*
>
> *the general character of the overlying strata in the catchment area from which the groundwater body receives its recharge*
>
> *those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.*

It should be noted that the concept of a "water body" is used throughout the Directive. In the case of groundwater the following definitions are provided:

> *"Aquifer" means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.*
>
> *"Body of groundwater" means a distinct volume of groundwater within an aquifer or aquifers.*

Many professional hydrologists will consider these terms to be vague. The intention of such is to ensure flexibility in defining boundaries for management purposes.

It has been suggested that much of this initial characterisation could be achieved through the application of relatively coarse overlays in a geographical information system. For example the application of land-use information in combination with geological and pedological data could provide an indication of the likely risk of groundwater contamination from agricultural activities. In instances where the initial characterisation is incapable of providing sufficient information, further characterisation should be undertaken.

2.2 Further Characterisation

Following this initial characterisation, member states shall carry out further characterisation of those groundwater bodies or groups of bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identification of any measures to be required under Article 11. Accordingly, this characterisation shall include relevant information on the impact of human activity and, where relevant information about:

- *geological characteristics of the groundwater body including the extent and type of geological units;*
- *hydrogeological characteristics of the groundwater body including hydraulic conductivity, porosity and confinement;*
- *characteristics of the superficial deposits and soils in the catchment from which the groundwater body receives its recharge, including the thickness, porosity, hydraulic conductivity, and absorptive properties of the deposits and soils;*
- *stratification characteristics of the groundwater within the groundwater body;*
- *an inventory of associated surface systems, including terrestrial ecosystems and bodies of surface water, with which the groundwater body is dynamically linked;*
- *estimates of the directions and rates of exchange of water between the groundwater body and associated surface systems; and*
- *sufficient data to calculate the long term annual average rate of overall recharge.*

In addition to the characterisation of the groundwater bodies themselves, competent authorities are required by Article 5 to carry out a review of the impact of human activity on groundwater in accordance with a scheme set out in Section 2.3 of Annex II.

2.3 Review of the Impact of Human Activity on Groundwaters

For those bodies of groundwater which cross the boundary between two or more member states or are identified following the initial characterisation undertaken in accordance with paragraph 2.1 above as being at risk of failing to meet the objectives set for each body under Article 4, the following information shall, where relevant, be collected and maintained for each groundwater body:

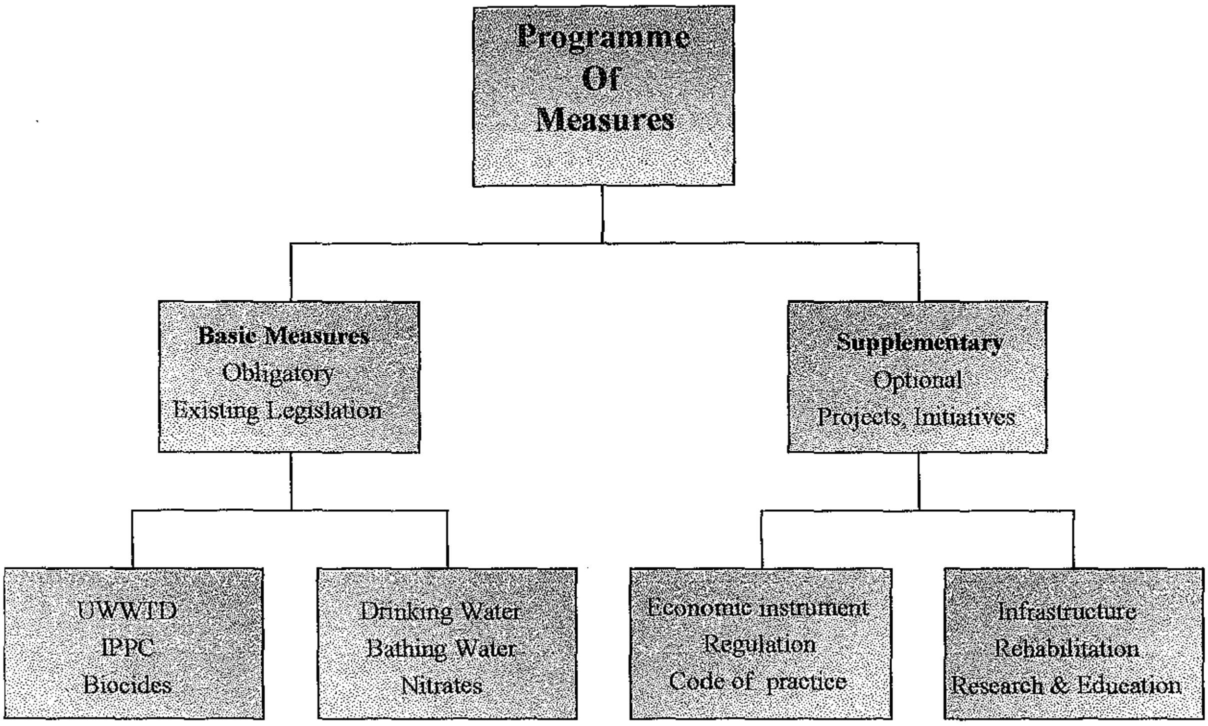
- *the location of points in the groundwater body used for the abstraction of water intended for human consumption providing more than an average of 10m^3 per day or serving more than 50 persons;*
- *the annual average rates of abstraction from such points;*
- *the chemical composition of water abstracted from the groundwater body;*
- *the location of points in the groundwater body into which water is directly discharged;*
- *the rates of discharge at such points;*
- *the chemical composition of discharges to the groundwater body; and*
- *land use in the catchment or catchments from which the groundwater body receives its recharge, including anthropogenic alterations to the recharge characteristics such as rainwater and run-off diversion through land sealing, artificial recharge, damming or drainage.*

On the basis of the characterisation and the review, competent authorities should be in a position to devise a draft programme of measures designed to achieve the environmental objectives. The data and information derived from this work will from part of the River Basin Management Plan, and must be made available to the public upon request.

PROGRAMMES OF MEASURES

Upon completion of the characterisation process, the competent authorities[2] will be required to draw up a draft programme of measures, which, on the basis of the available information, is designed to ensure the achievement of the environmental objectives. The Directive specifies the contents of the programmes of measures in Article 11 and Annex VI. These are summarised in Figure 1.

Figure 1 – Programmes of Measures



Remaining Directives

The Water Framework Directive will repeal the Groundwater Directive (80/68/EEC) and will probably lead to the abandonment of the much-praised proposal for a Groundwater Action Programme. Other instruments that are to be repealed by the Water Framework Directive are listed in Article 21 and include

- Surface Water Abstraction Directive 75/440/EEC,
- Freshwater Fish Directive 78/659/EEC,
- Shellfish Waters Directive 79/923/EEC, and
- Dangerous Substances Directive 76/464/EEC.

However other water quality Directives will remain in force, including the Bathing Water Directive (76/160/EEC – due to be revised), Nitrates Directive (91/676/EEC), the Urban WasteWater Treatment Directive (91/271/EEC) and the Drinking Water Directive (98/83/EC). The Framework Directive will require the continuing implementation of these measures to be integrated into the provisions of the River Basin Management Plans, and for the Plans to also take account of other relevant Directives

[2] Under the terms of Article 3 of the Directive Member States are required to divide up their territories into River Basin Districts and to identify a competent authority for each district. The competent authority will be responsible for the implementation of the Directive. Provisions are also contained in Article 3 for the co-ordinated management of River Basin Districts which are located in two or more Member States (International River Basin Districts)

including those on Integrated Pollution Prevention and Control (96/61/EC), Plant Protection Products (91/414/EC) and Biocides (98/8/EC).

Regulatory provisions

In order to achieve the environmental objectives specified in the Directive, the regulatory provisions contained within the Groundwater Directive are replaced by new obligations contained in Article 11, which states:

> 1. *Each Member State shall ensure the establishment for each River Basin District, ..., of a programme of measures, ..., with the aim of moving progressively towards achieving the objectives established under Article 4. ...*
>
> 2. *Each programme of measures shall include the "basic" measures specified in paragraph 3 below and, where necessary, "supplementary" measures.*
>
> 3. *"Basic measures" are the minimum requirements to be complied with and shall consist of:*

Basic measures that are relevant to groundwater quantity include:

> *(e)* *controls over the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water, including a register or registers of water abstractions and a requirement of prior authorisation for abstraction and impoundment. These controls shall be periodically reviewed and, where necessary, updated. Member States can exempt from these controls, abstractions or impoundments which have no significant impact on water status;*
>
> *(f)* *Member States shall also ensure, where practicable, the control and, where necessary, prevention of any other significant adverse impacts on the status of water identified under Article 5 and Annex II which would prevent the achievement of the objectives under Article 4 by, for example, a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community legislation. These controls shall be periodically reviewed and, where necessary, updated;*
>
> *(g)* *a prohibition of direct discharges of pollutants into groundwater subject to the following provisions.*
>
> *Member States may authorise re-injection into the same aquifer of water used for geothermal purposes.*
>
> *They may also authorise, specifying the conditions for:*
>
> - *injection of water containing substances resulting from the operations for exploration and extraction of hydrocarbons or mining activities, and injection of water for technical reasons, into geological formations from which hydrocarbons or other substances have been extracted or into geological formations which for natural reasons are permanently unsuitable for other purposes. Such injections shall not contain substances other than those resulting from the above operations.*

- *re-injection of pumped groundwater from mines and quarries or associated with the construction or maintenance of civil engineering works;*

- *injection of natural gas or liquefied petroleum gas (LPG) for storage purposes into geological formations which for natural reasons are permanently unsuitable for other purposes;*

- *injection of natural gas or liquefied petroleum gas (LPG) for storage purposes into other geological formations where there is an overriding need for security of gas supply, and where the injection is such as to prevent any present or future danger of deterioration in the quality of any receiving groundwater;*

- *construction, civil engineering and building works and similar activities on or in the ground which come into contact with groundwater. For these purposes, Member States may determine that such activities are to be treated as having been authorised provided that they are conducted in accordance with general binding rules developed by the Member State in respect of such activities;*

- *discharges of small quantities of substances for scientific purposes for characterisation, protection or remediation of water bodies limited to the amount strictly necessary for the purposes concerned;*

provided such discharges do not compromise the achievement of the environmental objectives established for that body of groundwater.

Member States may authorise artificial recharge or augmentation of groundwater bodies. The water used may be derived from any surface water or groundwater, provided that the use of the source does not compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater;

Considering each of these in turn. Article 11.3.e requires the implementation of a regulatory scheme for abstraction, impoundment and diversion. Many countries already operate such schemes, and therefore this article will not result in significant administrative change, although the rules for the granting of the relevant authorisations will need to be made compatible with the Directive.

Article 11.3.f is of a very general nature, and is intended to act as a "catch-all" provision which imposes the requirement on Member States to take action to achieve the environmental objectives. However, in accordance with the principle of subsidiarity, each Member State is allowed to adopt measures that are appropriate to their territory. For example, it is under this clause that Member States will be required to enact measures to control indirect discharges to groundwater that may cause a failure to achieve good groundwater chemical status.

The relevance of this clause to groundwater quantity issues may not be immediately apparent, but it is conceivable that measures to manage the level of infiltration and thus recharge could be considered under this article. Such measures might include a requirement for the use of permeable hard surfaces in new developments.

It is clear that the primary purpose of Article 11.1g is to preserve groundwater quality, and it is a direct replacement for the provisions of the Groundwater Directive (80/68/EEC), although the distinction between List I and List II substances no longer pertains. The list of circumstances under which authorisation of direct discharge is permissible is unlikely to prove sufficiently exhaustive, and the introduction of more general applicable criteria might prove to have been a better approach.

GROUNDWATER MONITORING

Article 8 of the Directive requires Member States to establish monitoring programmes for groundwater chemical status, quantitative status and for trend identification.

MONITORING CHEMICAL STATUS

The requirements for the monitoring of groundwater are specified in detail in Sections 2.4 and 2.5 of Annex V.

2.4 Monitoring of groundwater chemical status

2.4.1 Groundwater monitoring network

The groundwater monitoring network shall be established in accordance with the requirements of Articles 7 and 8. The monitoring network shall be designed so as to provide a coherent and comprehensive overview of groundwater chemical status within each river basin and to detect the presence of long term anthropogenically induced upward trends in pollutants.

On the basis of the characterisation and impact assessment carried out in accordance with Article 5 and Annex II, Member States shall for each period to which a River Basin Management Plan applies, establish a surveillance monitoring programme. The results of this programme shall be used to establish an operational monitoring programme to be applied for the remaining period of the Plan.

Estimates of the level of confidence and precision of the results provided by the monitoring programmes shall be given in the Plan.

2.4.2 Surveillance monitoring

Objective

Surveillance monitoring shall be carried out in order to:

- *supplement and validate the impact assessment procedure*
- *provide information for use in the assessment of long term trends both as a result of changes in natural conditions and through anthropogenic activity*

Selection of monitoring sites

Sufficient monitoring sites shall be selected for each of the following:

- *bodies identified as being at risk following the characterisation exercise undertaken in accordance with Annex II*
- *bodies which cross a Member State boundary.*

Selection of parameters

The following set of core parameters shall be monitored in all the selected groundwater bodies:

- *oxygen content*
- *pH value*
- *conductivity*
- *nitrate*
- *ammonium*

Bodies which are identified in accordance with Annex II as being at significant risk of failing to achieve good status shall also be monitored for those parameters which are indicative of the impact of these pressures.

Transboundary water bodies shall also be monitored for those parameters which are relevant for the protection of all of the uses supported by the groundwater flow.

2.4.3 Operational monitoring

Objective

Operational monitoring shall be undertaken in the periods between surveillance monitoring programmes in order to:

- *establish the chemical status of all groundwater bodies or groups of bodies determined as being at risk*
- *establish the presence of any long term anthropogenically induced upward trend in the concentration of any pollutant.*

Selection of monitoring sites

Operational monitoring shall be carried out for all those groundwater bodies or groups of bodies which on the basis of both the impact assessment carried out in accordance with Annex II and surveillance monitoring are identified as being at risk of failing to meet objectives under Article 4. The selection of monitoring sites shall also reflect an assessment of how representative monitoring data from that site is of the quality of the relevant groundwater body or bodies.

Frequency of monitoring

Operational monitoring shall be carried out for the periods between surveillance monitoring programmes at a frequency sufficient to detect the impacts of relevant pressures but at a minimum of once per annum.

2.4.4 Identification of trends in pollutants

Member States shall use data from both surveillance and operational monitoring in the identification of long term anthropogenically induced upward trends in pollutant concentrations and the reversal of such trends. The base year or period from which trend identification is to be calculated shall be identified. The calculation of trends shall be undertaken for a body or, where appropriate, group of bodies of groundwater. Reversal of a trend shall be demonstrated statistically and the level of confidence associated with the identification stated.

2.4.5 Interpretation and presentation of groundwater chemical status

In assessing status, the results of individual monitoring points within a groundwater body shall be aggregated for the body as a whole. Without prejudice to the Directives concerned, for good status to be achieved for a groundwater body, for those chemical parameters for which environmental quality standards have been set in Community legislation:

- *the mean value of the results of monitoring at each point in the groundwater body or group of bodies shall be calculated; and*
- *the mean value of these calculations for all monitoring points in the groundwater body or group of bodies shall demonstrate compliance with those standards in the manner prescribed in the relevant Directive.*

Subject to section 2.5, Member States shall provide a map of groundwater chemical status, colour-coded as indicated below:

Good	-	*green*
Poor	-	*red*

Member States shall also indicate by a black dot on the map, those groundwater bodies which are subject to a significant and sustained upward trend in the concentrations of any pollutant resulting from the impact of human activity. Reversal of a trend shall be indicated by a blue dot on the map.

These maps shall be included in the River Basin Management Plan.

2.5 Presentation of Groundwater Status

Member States shall provide in the River Basin Management Plan a map showing for each groundwater body or groups of groundwater bodies both the quantitative status and the chemical status of that body or group of bodies, colour coded in accordance with the requirements of sections 2.2.4 and 2.4.4. Member States may choose not to provide separate maps under sections 2.2.4 and 2.4.4 but shall in that case also provide an indication in accordance with the requirements of 2.4.4 on the map required under this section of those bodies which are subject to a significant and sustained upward trend in the concentration of any pollutant or any reversal in such a trend.

MONITORING QUANTITATIVE STATUS

The requirements for the monitoring of groundwater are specified in detail in Sections 2.2 and 2.3 of Annex V.

2.2 Monitoring of groundwater quantitative status

2.2.1 Groundwater level monitoring network

The groundwater monitoring network shall be established in accordance with the requirements of Articles 8 and 10. The monitoring network shall be designed so as to provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies including assessment of the available groundwater resource. Member States shall provide a map or maps showing the groundwater monitoring network in the River Basin Management Plan.

2.2.2 Density of monitoring sites

The network shall include sufficient representative monitoring points to estimate the groundwater level in each groundwater body or group of bodies taking into account short and long term variations in recharge and in particular:

- *for groundwater bodies identified as being at risk of failing to achieve environmental objectives under Article 4, ensure sufficient density of monitoring points to assess the impact of abstractions and discharges on the groundwater level*
- *for groundwater bodies within which groundwater flows across a Member State boundary, ensure sufficient monitoring points are provided to estimate the direction and rate of groundwater flow across the Member State boundary.*

2.2.3 Monitoring frequency

The frequency of observations shall be sufficient to allow assessment of the quantitative status of each groundwater body or group of bodies taking into account short and long term variations in recharge. In particular:

- *for groundwater bodies identified as being at risk of failing to achieve environmental objectives under Article 4, ensure sufficient frequency of measurement to assess the impact of abstractions and discharges on the groundwater level*
- *for groundwater bodies within which groundwater flows across a Member State boundary, ensure sufficient frequency of measurement to estimate the direction and rate of groundwater flow across the Member State boundary.*

2.2.4 Interpretation and presentation of groundwater quantitative status

The results obtained from the monitoring network for a groundwater body or group of bodies shall be used to assess the quantitative status of that body of those bodies. Subject to Section 2.5 below Member states shall provide a map of the resulting assessment of groundwater quantitative status, colour coded in accordance with the following regime:

Good - green
Poor – red"

The intention of the monitoring components of the Directive was to tread the very fine line between over-proscription and under-ambition. There is a considerable amount of technical interpretation required to make these provisions work properly.

CONCLUDING REMARKS

Although at the time of writing this paper the final text of the Directive has yet to be agreed, it is clear that many of the provisions contained in the Council Common Position will remain, and on this basis there can be no doubt that the Water Framework Directive will require Member States to make major changes to their water management practices.

Many of the requirements of the Directive will require the concerted input of expert hydrologists to ensure that the Directive is transposed into national legislation in a sensible and technically correct manner. However once this task has been completed, the hard work of carrying out the large amount of technical analysis that is required by the Directive will begin.

GOOD LUCK!

REFERENCES

LEGAL INSTRUMENTS TO BE REPEALED

Legal Instrument	Official Journal Reference
Surface Water Abstraction Directive 75/440/EEC	OJ L 194, 25.7.1975
Dangerous Substances Directive 76/464/EEC	OJ L 129, 18.5.1976
Information Exchange Decision 77/795/EEC	OJ L 334, 24.12.1977
Freshwater Fish Directive 78/659/EEC	OJ L 222, 14.8.1978
Surface Water Analytical Methods Directive 79/869/EEC	OJ L 271, 29.10.1979
Shellfish Waters Directive 79/923/EEC	OJ L 281, 10.11.1979
Groundwater Directive 80/68/EEC	OJ L 20, 26.1.1980

RELEVANT LEGAL INSTRUMENTS WHICH WILL REMAIN IN FORCE

Legal Instrument	Official Journal Reference
Bathing Water Directive 76/160/EEC	OJ L 31, 5.2.1976
Birds Directive 79/409/EEC	OJ L 103, 25.4.1979
Major Accidents (Seveso) Directive 96/82/EC	OJ L 10, 14.1.1997
Environmental Impact Assessment Directive 85/37/EEC	OJ L 175, 5.7.1985
Sewage Sludge Directive 86/278/EEC	OJ L 181, 8.7.1986
Urban Waste Water Treatment Directive 91/271/EEC	OJ L 135, 30.5.1991
Plant Protection Products Directive 91/414/EEC	OJ L 230, 19.08.1991
Nitrates Directive 91/676/EEC	OJ L 375, 31.12.1991
Habitats Directive 92/43/EEC	OJ L 206, 22.7.1992
Integrated Pollution Prevention Control Directive 96/61/EC	OJ L 257, 10.10.1996
Biocides Directive 98/8/EC	OJ L 123, 24.04.1998
Drinking Water Directive 98/83/EC	OJ L 330, 05.12.1998

COMMISSION PROPOSAL FOR A WATER FRAMEWORK DIRECTIVE

Initial Proposal - COM(97) 49 final - OJ C 184, 17.06.1997
Amendments in respect of Dangerous Substances - COM(97) 614 final - OJ C 016, 20.01.1998
Detailed proposal for Annex V - COM (1998) 76 - OJ C 108, 07.04.1998

COUNCIL COMMON POSITION ON THE WATER FRAMEWORK DIRECTIVE

Common Position (EC) No .. /99 adopted by the Council on .... with a view to the adoption of Directive 1999/ /EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy (Document Reference 9085_99)

WEBSITES

http:\\www.europa.eu.int – main site of the European Community, good source of legal texts
http:\\www.environment-agency.gov.uk – Environment Agency for England and Wales web site
http:\\www.eea.eu.int – European Environment Agency web site

PERSONAL INFORMATION

James Hunt works for the European and International Commitments team in the Environment Agency for England and Wales. The team is part of the Environmental Monitoring and Assessment function which is in turn part of the Environmental Strategy Directorate.

James was part of the United Kingdom team which negotiated and partly developed the Directive from June 1997 – June 1998 and has subsequently acted in a consultative capacity to the UK Department of Environment Transport and the Regions. James was formerly part of the team responsible for the introduction of the Special Waste Regulations in England and Wales. Prior to this he worked in the field of waste management for 6 years.

James Hunt
Senior Scientist
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS32 4UD
United Kingdom

Tel: 00 44 1454 878462
E-mail: james.hunt@environment-agency.gov.uk

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Stephen Reeves - Department of the Environment Transport and the Regions

2. The EU Water Framework Directive in Ireland

David Moore, Department of the Environment & Local Government

Overview of Water Framework Directive

IAH Seminar
11 April 2000

David Moore
Department of Environment and Local Government

procedure

- *Commission proposal* — *Feb. 1997*
- *Council's Common Position* — *Oct. 1999*
- *Parliament's Opinion (2nd)* — *Feb. 2000*
- *Co-Decision Procedure* — *2000*

Principal Objectives:

- ***Protect and improve aquatic ecosystems***
- ***Promote sustainable water use***
- ***Alleviate impacts of floods and droughts***

Applies to:

- *Quality and Quantity*
- *Inland surface waters, transitional waters, coastal waters and groundwaters*

Main Provisions of the Directive

- *River Basin Management*
- *Environmental Objectives*
- *Assessment of characteristics of river basins and human impacts*
- *Monitoring of status of surface and groundwaters*

Main Provisions (contd.)

- ***Establishment of Programme of Measures***
- ***River Basin Management Plans***
- ***Public Consultation***

Article 3.
River Basin Districts

- ***M.S. identify river basins and assign to RBD***

- ***RBD to include associated groundwaters and coastal waters***

- ***M.S. identify Competent Authorities for RBDs***

Article 4. Environmental Objectives

M.S. shall aim to achieve the objective of:

- ***Good surface water status***
- ***Good groundwater status***
- ***Comply with any standards and objectives for protected areas***

Article 4
OBJECTIVES

Groundwater

- prevent deterioration of groundwater status
- restore polluted bodies of groundwater
- ensure a balance between abstraction and recharge of groundwater
- aim of achieving good groundwater status (16 years)
- reverse any sustained upward trend in pollutants

Definition

Good Groundwater Status

- status achieved by a groundwater body when both its quantitative status and its chemical status are at least good.

Good Quantitative Status

- The level is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction

- does not cause:
- -breach of Art 4 objectives
- -diminution in the status of such waters
- -damage to terrestrial ecosystems

Good Chemical Status

Is such that the concentration of pollutants

- do not exhibit the effects of saline or other intrusion
- do not exceed the Quality Standards under other EC legislation

- would not result in failure of Art.4 EQO's or of ecological / chemical quality for surface waters
- would not result in damage to dependent terrestrial ecosystems

Article 5. Characteristics of RBDs

- *Analysis of Characteristics*
- *Review of Impacts*
- *Economic Analysis*

ANNEX II
1. Initial characterisation of groundwaters

- In order to assess use and degree of risk MS shall identify:
- location/boundary of the groundwater body
- pressures on groundwater
  - diffuse and point sources
  - abstractions
  - artificial recharge
- general character of the overlying strata in the recharge area
- those groundwater bodies for which surface water and terrestrial ecosystems are dependent

Further characterisation for groundwater bodies at risk

[redacted]

- the impact of human activity
- extent and type of geological units and their hydrogeological characteristics
- vulnerability of the recharge area

- stratification characterisitics of the groundwater
- an inventory of associated surface water systems and ecosystems

- estimates of direction and rate of exchange of water (S/G)
- data to calculate long term annual average rate of recharge

Annex II
2. Review of human activity on groundwater

For transboundary and groundwaters at risk of failing to meet Art. 4 objectives

Information required:

- abstraction points >10 m^3/d or 50 persons
- annual average rates and chemical composition of water abstracted
- location points,rate of discharge and chemical composition of water discharged
- land use in the catchment

Art. 6
Register of protected areas

Within each RBD establish a register of protected areas as per Annex IV

Includes areas for the abstraction of water and NVZs, (bathing waters, habitats etc.)

Article 7
Abstraction of Drinking Water

- *Identify > 10m3 / day*
- *Monitor > 100m3 / day*
- *Comply with Art. 4 objectives and EU standards for drinking water sources*
- *Ensure protection for such waters to avoid deterioration*

Article 8
Monitoring

M.S. shall provide an overview of water status by monitoring:

- ***for groundwaters - chemical and quantitative status***

Annex V Monitoring Quantitative Status

Monitoring network designed:

- to assess the quantitative status including potential available resource

with sufficient density of sites:

- to estimate impacts on groundwater levels

at frequency:

- to take account of the variation in recharge

Monitoring of Chemical Status

Monitoring network designed

- to provide comprehensive overview of chemical status in each RBD and
- to detect long- term induced upward trends in pollution

Surveillance Monitoring (overview)

- to validate the impact assessment procedure
- for use in the assessment of long term trends arising from natural and anthropogenic impacts

Monitoring of Chemical Status (contd.')

- Surveillance monitoring core parameters:

  DO, pH, cond'., NO3, NH4 and those indicative of impacts

- Operational Monitoring (risk areas)
  - to establish the chemical status of all groundwater bodies at risk
  - to establish any long term anthropogenically induced upward trend in the conc of any pollutant
  - representative and sufficient frequency (min. once/year)

Article 11
Programme of Measures
Basic Measures

- *Measures to implement EC water legislation : NO3, UWW,*
- *To recover costs*
- *To meet objectives for waters abstracted for drinking (art.7)*
- *authorisation/control of abstractions/impoundments*
- *control of point/diffuse discharges*
- *prohibition of direct discharges to groundwater*

Article 13
River Basin Management Plans

- *A general description of the characteristics of the RBD*
- *Summary of pressures /impacts*
- *Map of : protected areas*
  monitoring network
  status of:
  surface waters
  groundwaters
  protected areas
- *Summary of programmes of measures etc. etc.*

Article 14
Public Information and Consultation

Publish draft RBMP for comment at least one year before adoption

Article 16
Strategies against Pollution (Priority Substances)

Cion shall submit Proposals for:

- ***Priority list of substances***
- ***Control of sources, Point and Diffuse, by Product control/ ELVs***
- ***EQSs for surface waters, sediment / biota***

3. Implementing Groundwater Aspects of the Nitrates Directive

Vincent Fitzsimons, Hydrogeologist, Geological Survey of Ireland

GROUNDWATER ASPECTS OF THE NITRATES DIRECTIVE

Vincent Fitzsimons, Geoff Wright, and Donal Daly
Groundwater Section, Geological Survey of Ireland

ABSTRACT

The choice of scale in delineating groundwater nitrate vulnerable zones in the Republic of Ireland can be influenced by the national distribution of intensive agriculture, aquifer categories and subsoil permeability and thickness. Regional-scale NVZs, spanning entire aquifers or hydrological sub-catchments, may be required in some problem areas of the south and east where intensive agriculture, regionally important aquifers and extremely to moderately vulnerable groundwater coincide. Local-scale vulnerable zones, based on the capture zones of public supplies, are recommended in problem areas in poor and locally important aquifers. Local-scale vulnerable zones are also recommended in regionally important aquifers in the north and west of the country, where agriculture is less intensive. Data from public groundwater supplies are likely to be the best means of identifying problem areas. Some consideration of the origin of the nitrate problem in each vulnerable zone may help focus Action Programmes on the key contaminant sources, and minimise unnecessary prohibitions on agriculture in an area.

Disclaimer: This paper represents the views and considerations of the authors only, and is not a representation of national policy.

1 INTRODUCTION

1.1 OBJECTIVE

In 1991 the Council of the European Communities adopted a Directive aimed at reducing water pollution caused by, or induced by, nitrates from agricultural sources. It was also aimed at preventing further such pollution. This Directive is entitled 'Council Directive of 12 December 1991 Concerning the Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources (91/676/EC)', but is more commonly termed the 'Nitrates Directive'.

Article 3 (2) of the Directive states that:

> '...*Member States shall .... designate as vulnerable zones all known areas of land in their territories which drain into the waters identified ...[as exceeding certain criteria in relation to nitrates]...and which contribute to pollution [by nitrogen compounds]...*'

Article 5 and Annex III of the Directive require the development of agricultural 'Action Programmes' to be implemented within each vulnerable zone.

The Geological Survey of Ireland (GSI) has been asked by the Department of the Environment and Local Government (DELG) to advise and assist in relation to the identification of affected groundwaters and to assist in developing a set of guidelines for the delineation of 'vulnerable zones' around aquifers and around specific groundwater drinking supplies of concern.

This paper aims to summarise groundwater issues relevant to implementation of the Nitrates Directive in the Republic of Ireland. It is focussed on the issues concerned with vulnerable zone designation. However, it is not a representation of national policy.

1.2 KEY ISSUES

Implementation has not proved straightforward, either in the Republic of Ireland, or in several countries across the EU. This is primarily because of differing interpretations of the definition of the 'waters' which require vulnerable zone delineation.

Key questions which need to be addressed:

- How do we define 'waters'?
- Once 'waters' have been defined, how should local hydrogeological conditions be taken into account?
- Once 'waters' have been defined, can we differentiate different types of nitrogen release (i.e. between point and diffuse sources)?

Annex I of the Directive provides some guidance. It states that, in relation to groundwater:

> *Waters referred to in Article 3(1)... [include]... groundwaters containing more than 50 mg/l nitrates or ..[which]..could contain more than 50 mg/l nitrates if action pursuant to Article 5 [outlining Action Programmes] is not taken....In applying these criteria, Member States shall also take account of:*
>
> 1. *the physical and environmental characteristics of the waters and land;*
> 2. *the current understanding of the behaviour of nitrogen compounds in the environment (water and soil);*
> 3. *the current understanding of the impact of the action taken pursuant to Article 5.*

Annex I clearly confers wide discretion on members states in the identification of affected waters, but requires that due regard be had to nitrate characteristics and contamination patterns, and to interpretations of the likely effects of the Action Programmes in relation to Irish hydrogeological conditions and farming practices. These issues will be examined in Sections 2, 3, and 4 below and summarised in Sections 5 and 6.

2 NITROGEN IN THE SOIL-WATER ENVIRONMENT

2.1 NITROGEN SPECIES

Aside from gases, nitrogen (N) exists principally as two forms in the soil-water environment: organic (humus) and mineral (nitrate and ammonium). The organic form is generally considered immobile.

Ammonium can be held on the exchange complex of soils and is therefore not subject to leaching losses. Ammonium can also be fixed by expandable clay minerals. Nitrate, on the other hand, is a conservative ion and is not adsorbed on clay or organic matter (Kolenbrander, 1975). It is highly mobile and, under wet conditions, is easily leached out of the rooting zone and through soil and permeable subsoil. As such, the compound is not readily attenuated in the hydrogeological environment. Thus, nitrate is the main N compound of concern in implementing groundwater aspects of the Nitrates Directive and is the focus of the remainder of this paper.

Nitrate concentrations will be expressed in this document as concentrations of the ion, rather than as concentrations of the nitrogen component ('nitrate-N'). A nitrate concentration of 50 mg/l is equivalent to 11.3 mg/l nitrate-N.

2.2 SOURCES AND SINKS OF NITRATE

To understand nitrate in the environment, it is essential to understand the nitrogen (N) cycle. The aspects of this cycle in relation to 'natural' nitrate generation and loss can be divided into:

- *Internal transformations of N within the soil-plant system*; for example by the mineralisation of soil organic matter to nitrate in aerobic, oxidising conditions. The following formula is a simplification of the transformation of ammonium-N to nitrate-N:

  NH_4^+ (*Ammonium*) + $2O_2$ (*oxygen*) $\rightarrow$ NO_3^- (*nitrate*) + $2H^+$ + H_2O (*protons and water*)

- *Additions of N to the soil-plant system*; for example by symbiotic fixation from legumes.

- *Losses of nitrate from the soil-plant system*; by direct removal of harvested crops or animals, by leaching to groundwater or by denitrification. Leaching to groundwater is often enhanced in the winter, because of the greater potential for soil water movement, and because of the absence of N uptake by dormant plants (Neill, 1989). Henry and Meneley (1993) note that, in soil systems where an abundant supply of nitrate is available, and where the soil moisture content exceeds field capacity at a time of year when the temperature is conducive to microbial growth, denitrification can be 'very large and very rapid'. They go on to suggest that the soils most susceptible to denitrification have 'clay and heavy clay textures', and that bedrock aquifers overlain by more than 15m of this material can be classified as 'Low Risk' in terms of nitrate contamination in Western Canada. The following formula is a simplification of the process of denitrification by organic matter:

  $5CH_2O$ (*organic carbon*) + $4NO_3^-$ (*nitrate*) $\rightarrow$ $2N_2$ (*nitrogen gas*) + $4HCO_3^-$ + CO_2+3H_2O (*bicarbonate, carbon dioxide and water*)

- *Losses from groundwater or surface water*; generally only by denitrification, though a decrease in nitrate concentration can also be caused by dilution processes such as groundwater recharge. The uptake of N by plant growth in surface water is limited by the concentration of phosphorus (Lucey et al, 1997). In groundwater, Appello and Postma (1994) note that substantial nitrate reduction requires the presence of reduction potential within the aquifer material. They go on to indicate that solid phases which could provide such potential in aquifers are organic matter, pyrite, and Fe(II) silicates. Denitrification by organic matter is described above. Nitrate reduction in aquifers has been reported when coupled with the oxidation of sulphur and Fe(II) from pyrite (Robertson and Cherry, 1992).

  The link between iron and denitrification in aquifers is supported by a number of studies, which have noted that high iron/manganese and high nitrate levels do not normally co-exist in soil or groundwater, even in areas with a high percentage of cultivated land (e.g. Croll and Hayes, 1988, and Robertson, 1979).

Sources of nitrate can obviously also come from human activities such as storage and spreading of agricultural wastes, spreading of inorganic fertilisers, urban centres, sewerage systems, and industry.

Clearly, the Nitrates Directive is focussed towards agricultural sources. There is therefore some potential for debate as to whether a nitrate problem in a given area has originated from agriculture or from, for example, a sewerage system. However, a judgement of the European Court of Justice (Case C-293/97) stated that, as long as agricultural sources are believed to comprise a "significant contribution", it is not necessary for a Member State to determine precisely what proportion of the pollution in a water body is attributable to nitrates of agricultural origin, nor is it necessary for a Member State to determine that the cause of such pollution is exclusively agricultural.

Nevertheless, it is of benefit to examine the source of the nitrates problem in any given vulnerable zone, as part of the implementation procedure. Studies of this kind can help focus the Action Programmes required as part of the Nitrates Directive on key issues. Further, they can help implement additional measures to those outlined in Annex III of the Directive if some or all of the sources of nitrate are considered to be unrelated to agriculture. To this end, potential sources are commonly grouped into point and diffuse sources and organic and inorganic sources. Some examples are provided below:

	Point Sources	Diffuse Sources
Organic Sources	Sewage: On-site wastewater treatment systems Sewage lagoons Leaky Sewers Farmyard: Manures and slurries Silage effluent Dirty water Waste disposal sites. Contaminated surface water. Industry.	Organic wastes spread on land: Manure Slurry Silage effluent, blood, etc Sewage sludge, etc Soil organic matter. Urban areas (effectively an agglomeration of point sources). Geological sources.
Inorganic sources	Waste disposal sites Industry.	Inorganic fertilisers spread on land. Rainfall. Geological sources[1]

2.3 NITRATE LEVELS IN IRISH GROUNDWATER

The Environmental Protection Agency (EPA) produced a set of documents in 1997 containing a summary of available nitrate concentrations from selected groundwater drinking supplies in each county in Ireland up to and including 1995. In a review of these reports, Wright (1997) identified 28 out of 1297 (2%) supplies as 'List A', where measured concentrations were regularly or frequently in excess of 50 mg/l nitrate. An additional 98 supplies (8%) were grouped within 'List B', where measured concentrations occasionally exceeded 50 mg/l but which were regularly in excess of 25 mg/l. Both List A and List B supplies were considered as having nitrate levels of 'serious concern'.

More significantly, 82% of the supplies of 'serious concern' occurred in east Munster (Cork South, Cork North, Tipperary, and Waterford) and Leinster. Indeed, four counties in the east and south - Wexford, Carlow, South Cork, and Louth - contributed 49% of all supplies of serious concern. In contrast, three counties in the north west - Mayo, Sligo, and Leitrim - had no evident nitrate problems at all. It must be stressed that Wright's study did not provide a definitive list of problem supplies, nor was the strategy behind the categorisation intended to be final. However, it is clear that the supplies with nitrate problems are concentrated in the east and south.

Data from subsequent sampling undertaken by the EPA between 1995 and 1997 (Lucey et al.,1997) indicated a similar distribution. Average nitrate levels exceeded 25 mg/l in 17% of the 193 supplies sampled nationally, and exceeded 40 mg/l in 5% of the total. Further, 85% of supplies where average nitrate levels were in excess of 25 mg/l were located in Leinster and east Munster. They concluded that 'there was no widespread pollution of particular aquifers although elevated values (i.e. with mean concentrations >50mg/l) were found in Carlow, Kildare, Limerick and Louth.'

Page and Keyes (1999) have noted a generally increasing trend in County Offaly since the late 1980's. They estimate that average nitrate concentrations in springs and shallow wells across the county rose from 21 mg/l to 32 mg/l between 1991 and 1997.

[1] Rocks laid down with a high organic debris content, and their associated subsoils and soils, can have a high N content. Coal, for example has a natural N content of up to 30,000 ppm (Wlotzka, 1972). Groundwater in lignite beds in Canada has been found with nitrate concentrations of up to 100 mg/l (Power, et al. 1974). Though such rocks are rare in the Republic of Ireland, these works do suggest, for example, that peat is likely to be a source of geological nitrogen.

2.4 NITRATE LEVELS IN IRISH SURFACE WATER

Nitrate concentrations in surface water are regarded as less of a problem than those in groundwater. However, the distribution of higher concentrations is very similar to that of groundwater. Data provided by Lucey et al. (1997) indicates that typical nitrate levels between 1979 and 1997 were in the order of 2 to 4 mg/l in rivers in the south-east of the country, but between 0.5 mg/l and 1 mg/l in the west. They go on to state that 69% of the rivers and streams where concentrations exceeded 25 mg/l in at least one sample were located in the east and south east.

3 AGRICULTURE AND NITRATE LOSSES IN IRELAND

3.1 DISTRIBUTION OF NITROGEN LOSSES FROM DIFFUSE SOURCES

Nitrogen loss to water is believed to have increased several fold over the past 50 years in Ireland, with agriculture accounting for over 60% of the total nitrate loss to water. Nationally, the total N inputs in 1988 were 684,000 tonnes, with approximately 75% of these inputs lost to water and the atmosphere. (Culleton and Tunney, 1995).

Further, most of these losses are likely to be concentrated in areas of the south and east, where agriculture is more intensive (e.g. counties Carlow and Louth). This distribution matches the distribution of groundwater supplies and surface water samples where nitrate levels have been elevated (refer to Sections 2.3 and 2.4). Neill (1989) provides evidence to support the link with intensive agriculture, suggesting that a positive correlation exists between the nitrate levels in the rivers in the south-east and the proportion of land in their catchments which are given over to tillage. He goes on to suggest that, in the early 1980's, mean N loss to rivers in the south-east was 2 kg/ha/year from unploughed land, but 76 kg/ha/year from ploughed land.

Nevertheless, the potential for nitrate contamination is not as high as in some other member states of the EU, because agriculture is generally less intensive in this country. Daly and Daly (1984) note that, for example, 90% of good lowland soils in Ireland are used for grass. Even in Carlow and Wexford, comprising some of the most intensively-farmed land in the country, only about 30% of land is used for tillage crops. Daly and Daly (1984) go on to compare these figures with the situation in England, where high nitrate levels are found in regions where arable farming comprises over 60% to 90% of the area.

3.2 POINT SOURCES vs. DIFFUSE SOURCES

There is no research available for the Republic of Ireland as a whole on the relative proportion of groundwater supplies contaminated by point sources and diffuse sources. Such an assessment would be very difficult, partly because the results would depend strongly on the location of sampling points. Researchers in Ireland have generally come to discount data from private supplies when considering regional contaminant patterns, as many of these supplies are likely to have been polluted by local point sources such as septic tanks or farmyard effluent. This is primarily believed to be due to poor location and construction of the private supplies.

This seems to be generally supported by the results of a study undertaken by Coxon and Thorn (1991) in the east of Ireland, using chemical data from seventy domestic and farm water supply wells in the Curragh sand/gravel aquifer (Kildare) and Barrow Valley sand/gravel/limestone aquifer (Carlow). They note that 'chemical parameters which tend to be associated with point sources of contamination, including potassium, sodium, and chloride, [were] more frequently elevated in the high nitrate wells'. They also note that 'faecal bacteria....which are not associated with contamination by chemical fertilisers or the release of soil nitrogen...were found in over half of the seventy sites.' They provide a preliminary conclusion that 'while the intensity of agricultural land use (fertiliser usage and the proportion of arable land) is clearly of significance, many of the pollution problems appear to be associated with poor management of agricultural and human wastes and improper siting of wells.'

The incidence of point source contamination of public groundwater supplies is generally considered to be lower. This is because public supplies are generally more carefully constructed and located. Further, the higher abstraction will tend to draw in more groundwater recharge to these supplies, allowing for greater dilution of individual point source contributions. Nevertheless, Fitzsimons (2000) estimated, in a limited desk-based review of available chemical data, that point sources were likely to provide an important contribution to contaminant levels in at least 33% of public and group scheme groundwater supplies in Co. Laois where nitrate problems were identified.

Note that the Directive does not differentiate between point and diffuse agricultural pollution. However, point source contamination of groundwater appears to be significant in this country, and it follows that it will often be important to identify the source of nitrate release prior to deciding on the most appropriate scale of NVZ delineation and associated Action Programmes. This issue is best examined during the NVZ delineation process using a combination of on-site hazard surveys together with assessments of water quality data. The water quality assessments should include a wide range of chemical parameters alongside nitrate data.

The GSI has developed a list of key indicators of contamination from agricultural or domestic wastes to help in this type of water quality assessment. Threshold concentrations for these indicators have also been identified to help indicate situations where significant contamination is occurring, even if maximum admissible concentrations have not yet been exceeded. The importance and usage of these indicators is well established in the literature, and Box 1 provides a summary guide.

Box 1: Assessing a problem area using contaminant indicators (adapted from Daly, 1996)

E. coli present ⇨ organic waste source nearby (except in karst areas), usually either a septic tank system or farmyard.

E. coli absent ⇨ either not polluted by organic waste or bacteria have not survived due to attenuation or time of travel to well greater than 100 days.

Nitrate > 25 mg/l ⇨ either inorganic fertiliser or organic waste source; check other parameters.

Ammonia > 0.15 mg/l ⇨ source is nearby organic waste; fertiliser is not an issue.

Potassium (K) > 5.0 mg/l ⇨ source is probably organic waste.

K/Na ratio > 0.4 (0.3 in many areas) ⇨ Farmyard waste rather than septic tank effluent is the source. If < 0.3, no conclusion is possible.

Chloride > 25-30 mg/l ⇨ organic waste source. However this does not apply in the vicinity of the coast (within 20 km at least).

Thorn and Hanna (1989) provide a cautionary note that a consideration of the natural occurrence of some of these indicators (potassium in mudstones, for example) is required as part of the assessment process.

Page and Keyes (1999) provide some good examples of the use of contaminant indicators in assessing the influence of point sources on nitrate concentrations in public groundwater supplies in Offaly. The paper also demonstrates the use of the Water Pollution Acts to address the problem of point sources. In one example, several farms within the catchment of a supply were served with notices under the Water Pollution Acts and subsequent nitrate concentrations in the supply decreased notably within a few weeks.

4. IRISH HYDROGEOLOGICAL CONDITIONS

The Irish hydrogeological environment has some unusual characteristics which set it apart somewhat from most of the EU. In accordance with Annex I of the Nitrates Directive, these conditions can be taken into consideration when assessing the various implementation options available. This Section summarises some of the most important of these characteristics.

- Dilution is likely to be an important influence on nitrate levels in groundwater. The effective rainfall (rainfall less evapotranspiration) in Ireland is high. With the exception of the area around Dublin, the figure is usually greater than 350 mm/year. This could be compared with problem nitrate areas in the UK, where effective rainfall is much lower – 150 mm to 250 mm/year (Daly and Daly 1984).

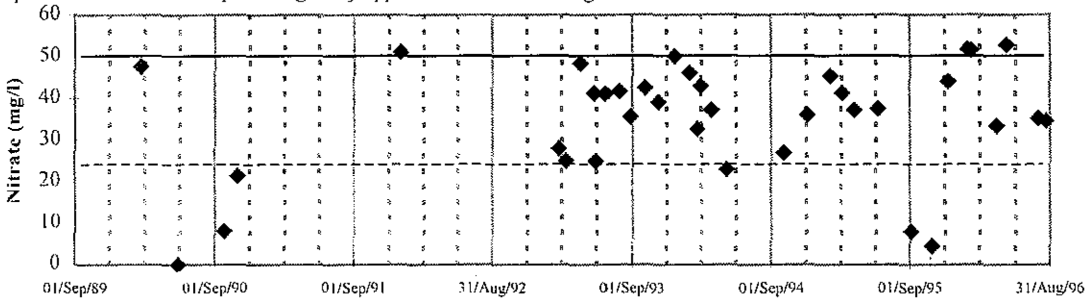
- Irish aquifers – particularly those currently exploited for drinking water supplies – are generally unconfined, or locally confined by till and/or peat. Unconfined situations are generally less conducive to the denitrification processes described in Section 2.2, because of the potential for dissolved oxygen replenishment by groundwater recharge.

- Subsoils are of varying thickness and permeability, but low permeability clay-rich subsoils in excess of 10m thickness are not uncommon. Groundwater below these subsoils is classified as having a 'low vulnerability' by the GSI (DELG/EPA/GSI, 1999). Recent work by Lee (1999) indicated that low vulnerability areas are usually characterised by pasture land, where high perched water tables, gley soils, rushes, etc. occur in undrained fields. Clearly, intensive agriculture is not commonly associated with such areas.

- Fissure permeability predominates. The only widespread aquifers exhibiting mainly intergranular permeability are the Quaternary sands and gravels (accounting for 25% to 30% of the national groundwater resource). Groundwater flow in bedrock aquifers is therefore concentrated in the zone of more enhanced fissure development close to the top of the rock and along fault zones. Daly (1995) speculates that perhaps up to 60% of groundwater flow occurs within 5m to 15m of the top of the rock.

- Most bedrock aquifers tend to have a low effective porosity, with unconfined storage coefficients expected to be less than 3%. This, along with the limited effective thickness of the aquifers, and generally high permeability bedrock fissures, results in rapid variations in flow conditions in bedrock aquifers. As a result, chemical concentrations can react rapidly to recharge events, resulting in sudden, large variations in concentration, or in the occurrence of isolated concentration peaks and troughs. An example is provided in Figure 1.

Figure 1: Groundwater Nitrate Concentrations from a Public Supply in Munster:
An example of a variable nitrates data set. Average is approximately 35 mg/l, but it is more important to note that the peaks regularly approach or exceed 50 mg/l.



- Flow paths are quite short in most situations. Flow paths in regionally important aquifers rarely exceed a few kilometres. Flow paths in poor aquifers may be only a few tens of metres long, with a high proportion of recharge discharging into the numerous streams and small springs that are present in these areas.

- Organic matter is not common in the matrix of Irish bedrock. It is also rare in most subsoil types, with the obvious exception of peat. Iron, however, occurs in many rock and subsoil types and is commonly associated with bedrock fissures and fracture zones. It is most prevalent in the dark muddy limestones, shales and sandstones, along with igneous and basement rocks. These rock types dominate the locally important and poor aquifers in Ireland.

- Groundwater usage for public supply varies widely across the country, ranging from less than 2% in Dublin to over 50% in several midlands counties and over 80% in Roscommon.

However, a relatively high proportion of housing is not supplied by mains water. It is estimated that over 200,000 - and perhaps considerably more - private wells exist across the country (Wright 1999). In Offaly, for example, it is estimated that 36% of the population is supplied by private wells (Page and Keyes, 1999). It is believed that a significant proportion of private wells in the country are contaminated by nearby point sources such as septic tank systems and farmyards.

- Groundwater is likely to comprise a high proportion of surface water flows, particularly in larger rivers flowing over regionally important aquifers. Daly (1994) estimated that groundwater provided an average of 50% of the total river flow between 1972 and 1981 at a gauge station on the lower reaches of the River Nore in the south-east of the country. Across the Nore basin as a whole, it is therefore likely that the proportion is higher than 50% downstream of regionally important aquifers, and lower than 50% downstream of the lower grade aquifer types. Surface water can also recharge groundwater flows in some situations, particularly in karstic aquifers.

In summary, Irish bedrock aquifers are highly heterogeneous, and no rock types are classified as non-aquifers. Failed wells can occur in the most important aquifers, while significant groundwater strikes can occur in aquifers which are generally poor. The implications for NVZ delineation are as follows:

- The potential for denitrification in regionally important aquifers is limited and unlikely to influence the size and location of NVZs, except in areas where these aquifers are confined.

- There is potential for denitrification, however, in waters recharging these aquifers through soils or subsoils with heavy clay textures. This potential is enhanced where increased thickness of these materials inhibits downward infiltration of water, and/or where the matrix of the material has nitrate reduction potential in the form of organic matter or iron (refer to Section 2.2). It is considered that, in the Irish context, this coincides with peat or with groundwater mapped as having 'low vulnerability', using the GSI terminology.

  There is also potential for denitrification in poor or locally important aquifers, where iron is found naturally and where groundwater residence times are long. An example occurs on the Castlecomer plateau, where locally important and poor aquifers occur in a layered sequence of Upper Carboniferous sandstones and shales, and where there is evidence of unusually old groundwater in places (Misstear et al., 1980). Levels of nitrate have been non-detectable in a public supply well located in this formation, even though the presence of ammonia concentrations of around 0.1mg/l suggest that a source of nitrogen is readily available (Fitzsimons, 2000).

- The very short flow paths in locally important and poor aquifers mean that problems identified from groundwater sampling at an individual supply can only be considered within the context of the catchment area for that supply.

- Conventional trend analysis of nitrate concentrations, and the analysis of statistical parameters such as maxima, minima, and mean values, is problematic. It is quite common for individual 'spikes' or 'dips' to interrupt otherwise quite even data. It is therefore considered preferable by the GSI to use a grouping system, such as that presented in Box 2.

Box 2: Example Classification of Public Groundwater Supplies, as used by the GSI (Adapted from Wright, 1997).

- **Category A**: Nitrate levels regularly exceed 50 mg/l
- **Category B**: Average nitrate levels exceed 25 mg/l and peaks regularly approach or exceed 50 mg/l.
- **Category C**: Average nitrate levels exceed 25 mg/l, peaks rarely approach 50 mg/l but trend gives cause for concern.
- **Category D**: Average nitrate levels <25 mg/l and peaks do not give cause for concern.

The example from Figure 1 would be included in Category B.

It is worth stressing that the heterogeneous nature of Irish groundwater flow patterns mean that data from any one monitoring point are unlikely to represent average or typical conditions in a groundwater system, unless water is drawn towards that point from a wide area. Thus, nitrate data from supplies with large abstractions are considered to give the best indication of general nitrate concentrations in groundwater (Daly, 1997). This is because they draw water from large catchment areas, where the impact of nearby point sources will be 'diluted' and is less likely to be evident. In contrast, while nitrate levels in small private supplies might reflect the overall situation in an area, they are more frequently likely to reflect the impact of nearby farmyards and septic tank systems. Monitoring wells, drilled and strategically-located specifically for the purpose of water quality sampling, are used in some countries for assessing regional-scale nitrate problems. However, these are less likely to be effective in most Irish situations because long-term pumping volumes will be a fraction of those from public supplies. Thus, the data from these monitoring points may not be representative of any significant area, and may be influenced by individual point sources, giving a potentially false impression of the regional situation.

It is also worth stressing that groundwater and surface water cannot be regarded as separate systems. Surface water nitrate concentrations, in particular those from larger rivers on more important aquifers, can give some assistance in assessing regional groundwater nitrate problems. In other situations, contaminated 'sinking' rivers may be contributing to nitrate problems in groundwater.

5 SUMMARY OF KEY FACTORS RELEVANT TO IMPLEMENTATION IN IRELAND

- There is evidence to suggest that losses of N from Irish agriculture are, and have been, significant, though perhaps on a smaller scale than elsewhere in the EU. These losses are likely to be concentrated in the more intensive farming areas of the east and south.
- Data from public water supplies, and especially those with the larger abstractions, give the best indication of general nitrate concentrations in groundwater across an area.
- Reviews of the available data up to the end of 1997 suggest that the nitrate problems occur in the same broad area as intensive agriculture – the east and south.
- A proportion of public supplies showing evidence of nitrate contamination are likely to have been affected significantly by contamination from point sources such as farmyards and septic tanks. The main body of the Nitrates Directive text does not mention any specific agricultural activities. The Action Programmes listed in Annex III are mainly focussed on the diffuse application of fertiliser and manure.
- Elevated nitrate concentrations in public supplies in locally important and poor aquifers are unlikely to reflect a regional-scale problem as, in these areas, groundwater flow is localised along short pathways.
- Areas mapped as 'low vulnerability' in the context of general groundwater contaminants, are unlikely to be at risk from nitrate contamination.
- Denitrification is not likely to be significant within the important aquifers themselves, except where they are confined. There is potential for denitrification in the locally important and poor aquifers, especially where they are confined.
- Surface water flow measurements and nitrate concentrations may help in understanding groundwater problems in certain situations.

6 DISCUSSION OF IMPLEMENTATION

The selection of areas for vulnerable zone designation should be based on existing nitrate monitoring data from public groundwater supplies. It is recommended that these data are best analysed using a phased approach. Phase I involves the identification of problem supplies. Phase II involves the assessment of these supplies in terms of the most appropriate method of NVZ delineation. Phase III involves the NVZ delineation process itself, while Phase IV involves the follow-up processes required by the Nitrate Directive.

Phase I - Identification of problem supplies: This is undertaken using all available nitrate data. It is recommended that this be undertaken using a grouping or ranking approach. Using the approach developed by the GSI as an example (refer to Box 1), Categories A and B would be identified as problem supplies.

Phase II - Assessment of NVZ delineation method for each problem supply. The following approach is recommended:

i. Acquire more data if the number of nitrate analyses is small or the data are old. Reassess the selection of the supply in the light of any additional data.

ii. Estimate the potential catchment area (Zone of Contribution) around each problem supply. This term relates to a larger area within which the actual Zone of Contribution (ZOC) will lie, and is a useful interim interpretation to help focus fieldwork and analysis. The delineation can be a desk-based exercise, and should be undertaken in accordance with DELG Guidelines (DELG/GSI, 2000). In brief, geological, hydrological and geomorphological features such as faults, catchment boundaries, springs and rivers are used, in combination with simple water balance estimates, as constraints on the boundary of the potential ZOC.

iii. Assess the influence of point sources on the nitrate concentrations, using a combination of:
   - full chemical analyses, and
   - on-site hazard surveys within the potential ZOC.

   If concentrations of nitrate in a problem supply can be linked very closely to a single point source or point sources, the NVZ designation process may be less important than removing or mitigating the source of pollution. If problems can be associated only partly with point sources, then NVZ designation should proceed to completion. In this situation, careful attention to the Action Programmes for the NVZ is recommended to address the issue of removing or improving the point sources, and to ensure that unnecessary restrictions on other farming practices are minimised.

iv. Decide on the scale of NVZ delineation in relation to the problem supply.

In locally important and poor aquifers, NVZ delineation will normally be specific to the ZOCs of problem supplies, in view of the localised nature of groundwater flow (refer to Section 4). Also, NVZ delineation will usually be specific to problem supplies in regionally important aquifers in the north and west of the country. This is because high nitrates are likely to be dominantly of point source or local-scale origin, as agriculture is generally less intensive and dilution is greater in these areas.

Problem supplies in regionally important aquifers in the south and east require a different approach, however. An analysis of the spatial distribution of all supplies (i.e. not simply problem supplies) across the aquifer is recommended, with particular attention focussed on data from the larger public supplies. Data from appropriate water quality monitoring stations in the main surface water discharge zones may also be useful in determining the nature of the nitrate source. Where the distribution of nitrate contamination suggests a regional-scale nitrate problem exists, and where this problem can be associated to some extent with diffuse sources, NVZs should be delineated for the entire aquifer. In some cases, particularly if surface water nitrate concentrations are of concern, consideration of an entire hydrological unit may be more appropriate. However, if the distribution suggests that problems are associated with discrete, separate areas within the aquifer, then supply-specific NVZs will probably be more appropriate.

Phase III - NVZ delineation:

- *Supply-specific NVZ:* The NVZ is the 'Zone of Contribution' (ZOC) with low vulnerability areas excluded. ZOCs are discussed in more detail in DELG/GSI (2000). These guidelines are based closely on the standard Source Protection Zone methodologies developed by the GSI (DELG/EPA/GSI, 1999), which should be familiar to most hydrogeologists working in Ireland over the past few years.
- *Aquifer-specific NVZ:* The NVZ comprises those areas where moderately to extremely vulnerable groundwater coincides with the extent of the aquifer. Some consideration of areas beyond the aquifer which supply recharge to that aquifer is also recommended, and it may be necessary to consider the entire hydrological unit within which the aquifer occurs. Guidelines are provided in DELG/GSI (2000b).

Phase IV – Follow-up Implementation

The Nitrates Directive does not simply require NVZ delineation. The Directivealso requires member states to:

- Continue monitoring and re-assessing all supplies of concern. [Articles 3(4) and 6].
- Draw-up a code of practice for all waters within 2 years. [Article 4].
- Draw-up Action Programmes for each NVZ within 2 years. [Article 5].
- Implement Action Programmes within 2 years of establishment. [Article 5].

7 CONCLUSIONS

NVZ delineation in relation to groundwater can be influenced by water quality data from public supplies, the location of these supplies in relation to areas of intensive agriculture and regionally important aquifers, and on their location in relation to areas of peat or thick, clay-rich subsoils. While the Directive does not differentiate between point and diffuse agricultural pollution, a consideration of the influence of point sources of contamination within an NVZ may enhance the effectiveness of the delineation process.

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4. Groundwater Jurisdiction: A Canadian Perspective

Ken Howard, University of Toronto, Ontario

GROUNDWATER JURISDICTION: A CANADIAN PERSPECTIVE

Ken W.F. Howard, University of Toronto Groundwater Research Group, University of Toronto at Scarborough, 1265 Military Trail Scarborough, Ontario, M1C 1A4, Canada

Abstract: Recent Canadian studies confirm that certain aspects of urban growth pose a serious threat to the quality and quantity of groundwater. While Federal, Provincial and Municipal laws exist that may limit impacts, this legislation is complex, limited in extent, and rarely acknowledges either the wide range of potential urban contaminants or the temporal dynamics of groundwater flow. For much of Canada, a perceived abundance of fresh water resources has led to widespread complacency with few Canadians regarding groundwater protection as a priority issue. In recent months, this view has apparently changed, in southern Ontario at least, with local residents visibly angered by proposals to build housing on the Oak Ridges Moraine aquifer. The ensuing campaign to "Save the Moraine", championed by citizens' groups and fuelled by the media is highly politicised and scorns scientific evidence showing potential impacts can be ameliorated. The battle has served, however, to highlight the archaic state of existing legislation for groundwater protection in the province. Indeed, Canada as a whole, sorely needs a broad, and scientifically based policy that will adequately protect all ground and surface water. Research and experience suggest that such a policy should be based on a standards of performance approach, and be policed at the provincial level. Standards would designate limits for the degree to which a change in land use would be allowed to degrade water quality, and may also require that total recharge remain unaltered on a sub-watershed basis. This type of approach would show respect for local hydrogeological conditions and encourage planning innovation. The approach would also encumber the proponent of land use change with the responsibility to perform appropriate sub-surface investigations and provide designs, monitoring programs and contingency plans that would enable environmental standards to be met for all time.

CANADIAN GROUNDWATER RESOURCES - A NEGLECTED RESOURCE

Canada is endowed with copious volumes of fresh water. Average annual precipitation is about 600mm across almost 10 million km^2 of territory (equivalent to 7% of the global land mass). Allowing for evaporation and transpiration losses, the national input of fresh water exceeds 3,000 cubic kilometres annually (Hare, 1984), a quantity that is 9% of the world's renewable fresh water supply. To complete the hydrologic cycle all this water ultimately enters the Pacific, Arctic and Atlantic Oceans at a mean rate close to 100,000 m^3 every second. Even recognising that Canadians are the world's second largest per capita users of water (360 litres per person for household use alone) it is readily estimated that only 2% of the nation's renewable input is withdrawn to meet human and industrial needs.

In many regards, it is the perceived abundance of fresh water in Canada that has caused the many water problems we face today. A noticeably lax attitude to water resource management and protection has allowed many rivers and lakes to become contaminated by industrial plant effluents, runoff from agriculture, urban and industrial areas and forestry, landfill leachates, inadequately treated sewage, and long-range transport of airborne contaminants (Government of Canada, 1991). There is also increasing evidence of groundwater contamination, a particular concern given that groundwater residence times are large and regularly exceed several hundred years. If it is assumed that the total volume of water in storage at any time (groundwater, surface water and ice) probably exceeds a staggering 300,000 km^3, mean residence time for all fresh water in Canada averages 100 years.

It is estimated that 90% of Canada's fresh water is stored as groundwater - primarily contained in clastic sedimentary rocks, limestones/dolomites (including karst), fractured crystalline rocks of the Canadian Shield, and glacial sediments. This fraction compares with approximately 4% stored in the nation's 100,000 glaciers and about 3 % stored, at any one time, in its numerous rivers and lakes. To help put these figures in perspective, it has been suggested that the lakes and rivers, which cover nearly 8% of the country, contain enough water to flood the entire nation to a depth of 2m (Science Council of Canada, 1988). If groundwater were described to similar effect, the water depth would approach 50m or more.

The most recent figures suggest that groundwater obtained from aquifers provides a domestic supply for between 25 and 30 % of all Canadians. The value varies regionally from 100% in Prince Edward Island to as little as 1% in the Northwest Territories and Nunavut. Almost 70% of those reliant on groundwater are rural users; in fact, over 80% of the rural population depend on groundwater for domestic use. Industrial use of groundwater is about 1% and partly reflects the large volumes of surface water used by thermal plants (electrical power generation).

In general, and as observed by Vonhof (1985), the attention paid by individual Provinces to the protection of groundwater resources is a function of its relevance as a source of potable water and the availability of alternate surface-water resources. Largely, it is the rural communities that have greatest dependence on groundwater; yet, in many Provinces with abundant surface water supply, it is precisely these stakeholders that have least influence on the decision-making process. Groundwater continues to be a neglected resource in Canada. Few Provinces maintain adequate groundwater monitoring networks (either quality or quality); few attempts have been made to document groundwater resources and the extent to which the potability of these resources is being compromised by pollutant sources. Moreover, while some Provinces argue that they "manage" groundwater resources, the truth is that most do little more than issue permits for water-taking. It is of little surprise that groundwater contamination is becoming a serious issue for concern.

SOUTHERN ONTARIO AND THE OAK RIDGES MORAINE

Until recently, groundwater resources and the threat of contamination would have barely raised an eyebrow for the vast majority of Canadians. In Toronto, for example, Canada's largest urban region, virtually all drinking water is drawn from Lake Ontario, and the risk of land use change to groundwater resources is regarded by many as of little consequence. In the past six months, this attitude has changed rapidly, with proposals by land developers to "sprout" housing along tracts of the Oak Ridges Moraine (Howard et al., 1995) (Figures 1 and 2), one of the Province's larger aquifers and the headwater source of many of the region's streams. "Concerned citizens", fired by activist groups and supported by the local press, began an intense campaign to "Save the Moraine" from urbanisation, an increasingly politically motivated movement that has brought the issue of groundwater protection to the public eye. In many regards, the groundwater science has been lost in the ensuing and highly contentious debate. Few protestors seem to care, for example, that the unusually detailed hydrogeological studies conducted as a prerequisite to development suggest potential problems are readily manageable and that impacts will be negligible. What has been highlighted, however, and brought to centre stage is the archaic state of existing groundwater legislation for much of the Province. In fact, somewhat ironically, the Oak Ridges Moraine is one of few areas in the Province where existing legislation provides groundwater with a significant degree of protection.

For the most part, the legislation is woefully inadequate. Comprising little more than a patchwork of statutes, policies, programs, regulations and guidelines, it clearly lacks the breadth, versatility and conviction to deal with the wide range of potential land-sourced contaminants (Howard, 1997a) and the dynamics of groundwater flow within frequently complex glacial aquifer systems. From a purely practical standpoint, prospective land developers find they are faced with a maze of legislation at virtually all levels of government (Howard, 1997b) while groundwater receives only piecemeal protection. The underlying problem is that there is no single body, either at the Provincial or Federal level, which is willing to take jurisdictional responsibility for the management and protection of groundwater resources.

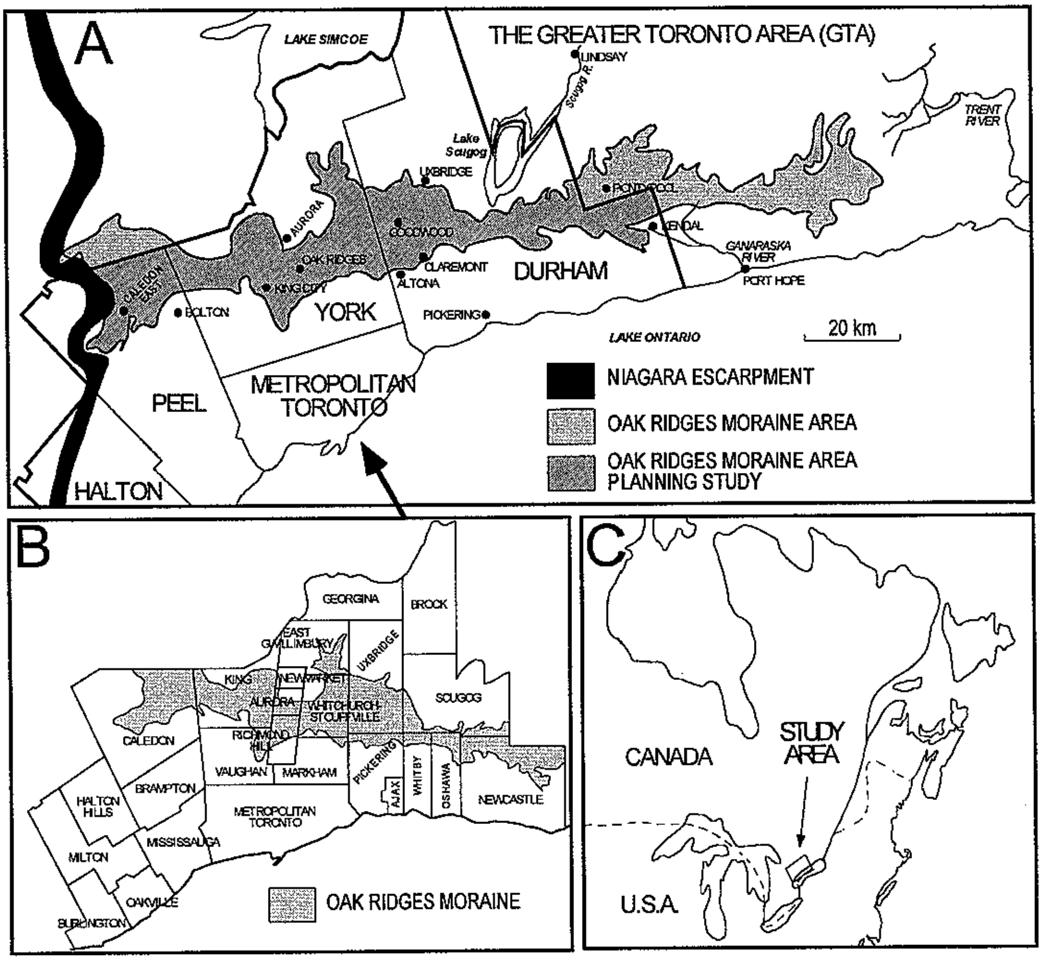

Figure 1. A) Location map showing the Oak Ridges Moraine (ORM) in relation to Metropolitan Toronto and the four Regions that together comprise the Greater Toronto Area (GTA). The Oak Ridges Moraine Planning study area refers to that part of the moraine contained within the GTA; B) Local Townships; and C) Regional location (after Howard et al., 1995).

ONTARIO'S LEGISLATIVE PROCESS

The urban planning process in Ontario, Canada's most populated Province, provides a good illustration of the complex and archaic state of the legislation that is supposed to protect groundwater. The 1995 Ontario Planning Act gives the Ministry of Municipal Affairs (MMA) responsibility for the approval of official plans, official plan amendments (OPAs), subdivisions, consents and zoning order amendments. In practice, approval authority for sub-divisions and, in some cases, OPAs is delegated to regional municipalities at the local level (Counties and Townships). By similar token, the Ontario Water Resources Act, the Environmental Protection Act, and the Environmental Assessment Act, all passed into law by the Provincial government in 1990, vests legislative responsibility for the management and protection of ground and surface water to the Ontario Ministry of Environment (MOE). Increasingly, the Ministry of Environment passes this responsibility on to the regional municipalities, despite the fact that few have either the expertise or the resource base to make informed decisions. Groundwater protection issues become further complicated and sometimes obscured when other agencies enter the picture. Regional municipalities are responsible for providing services such as water, sewage treatment, waste disposal and roads. Conservation Authorities become involved where land development is likely to affect valley lands and flood plains. The Ministry of Natural Resources (MNR) has no direct interest in water resources, but is responsible for protecting, aquatic habits, and areas designated as environmentally sensitive (ESAs) or determined to be of natural and scientific interest (ANSIs). MNR has also assumed primary responsibility for the protection of "special areas of local or Provincial interest". These areas include large moraine areas and selected watersheds/sub-watersheds, even though such areas receive this designation based largely on water resource issues - issues that should logically fall under the jurisdiction of MOE.

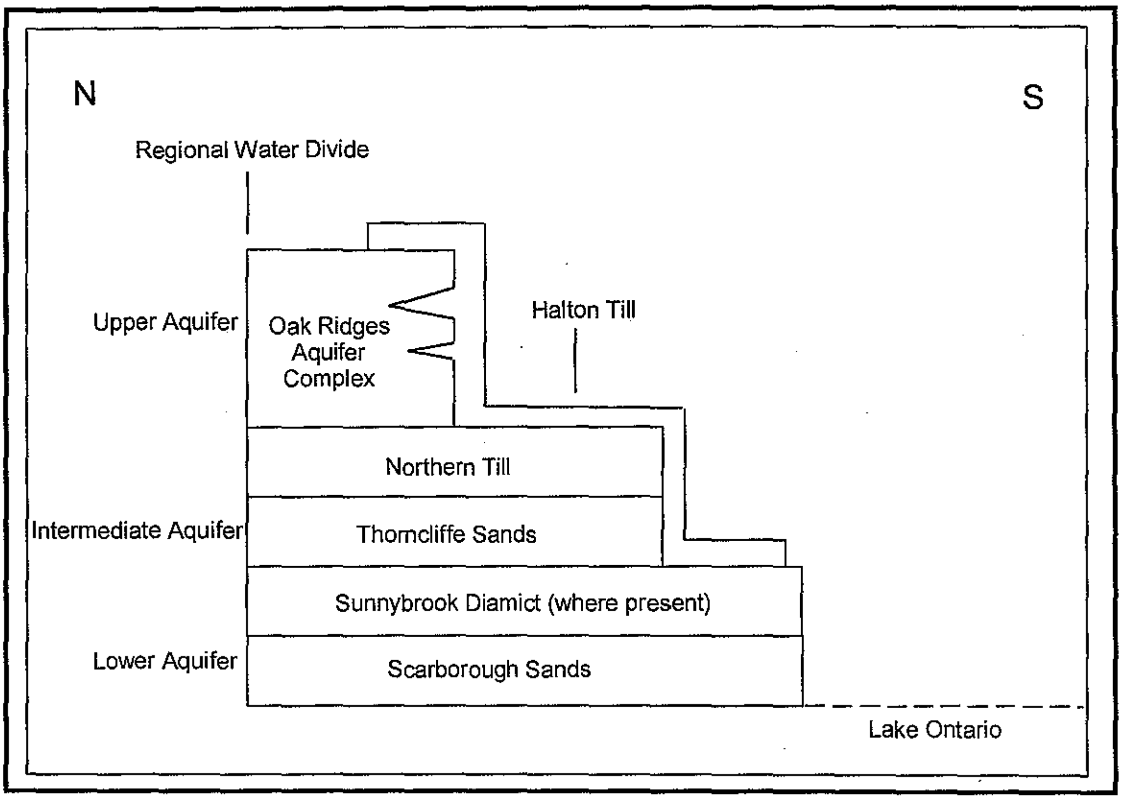

Figure 2. Schematic north-south section showing multi-layer aquifer system capped by the Oak Ridges Moraine aquifer.

Fortunately, some help is available to the prospective land developer in the guise of an unwieldy document published by the Ontario Ministry of Environment (previously the Ontario Ministry of Environment and Energy) (MOEE, 1995). This document was commissioned by the Office of the Provincial Facilitator of the Ministry of Municipal Affairs, and was prepared by external consultants to guide land development applicants (and likely, no doubt, confused government personnel) through those aspects of the planning process that are relevant to groundwater. While the document is clearly useful for steering prospective developers through a veritable minefield of statutes, policies, programs, regulations and guidelines, it also allows the many shortcomings and inconsistencies of the process to be identified. For example, groundwater protection is not explicitly recognised in the urban planning process, and hydrogeological investigations are required only where one or more of the following conditions are met:

i) Groundwater is required for domestic supply (in which case the adequacy of the resource and potential interference problems must be examined);

ii) Sewage systems are proposed that require subsurface disposal of waste via leaching beds or surface disposal using spray irrigation (in which case, impacts must fall within Provincial guidelines);

iii) Soil and/or ground water at the site is known or suspected to be contaminated; or

iv) The site is located on areas that have been designated as hydrogeologically sensitive and therefore of "special" interest to the Province.

In effect, for a major urban expansion comprising fully serviced subdivisions, arterial roads and highways, parks, shopping malls and gas stations, groundwater protection becomes a consideration (and often little more than that) only in areas that have been designated as "hydrogeologically sensitive". Perhaps more seriously, this designation is normally assigned to "recharge areas of major aquifers", in the misguided belief that

a) Recharge to aquifers occurs exclusively in areas where aquifer material is exposed i.e. "outcrops" at the surface; and

b) Areas where recharge to underlying aquifers is highest are the most sensitive and thus most in need of groundwater protection.

Quite to the contrary, many studies including Gerber and Howard (1996,1997) and Howard and Gerber (1997) have shown that with respect to a), significant quantities of recharge can occur through finer-grained aquitard material, including dense till deposits previously regarded as "impervious" to water. Furthermore, while it may be appropriate to protect high recharge areas in some circumstances, there can be many situations where poorly recharged areas deserve greatest protection. For example, high rates of infiltration and/or high aquifer storage volumes provide for greater attenuation of contaminants, and will result in less serious impacts on water quality. By similar reasoning, water levels in unconfined aquifers underlying recharge areas may, by virtue of a high specific yield, be less susceptible to gains or losses in recharge than water levels in semi-confined aquifers. In effect, it is the weaker aquifer with low recharge and low groundwater fluxes that is likely to be the most affected i.e. is most "sensitive" to any sort of land use change. This runs contrary to popular perception.

A PROPOSED SOLUTION

It goes without question that Canada is in serious need of a broad, and scientifically based legislation that will provide for the protection and management of all ground and surface water. The questions to be asked are,

"What type of legislative policy is appropriate?"

"What level of government should enact the legislation?"

"Is there anything to be learnt and possibly salvaged from the piecemeal legislation presently in place?"

Groundwater protection measures that choose to ban or limit certain land use practices in areas that have been designated or classified, as "recharge" zones or areas "vulnerable to pollution", are examples of "standards of practice". Wellhead protection methods (Cleary and Cleary, 1991) e.g. zones of contribution (ZOCs) (USEPA, 1987, 1993), and source protection zones (SPZs) (NRA, 1992) also fall into this category. Methods based on standards of practice are welcomed by planners as they are easy to administer and are readily incorporated into planning tools such as geographical information systems, thus enabling decisions to be made rapidly with a minimal degree of subjectivity. As groundwater protection measures, they provide no information on the degree of impact anticipated, either in the aquifer or receiving wells, and tend to be effective only in geologically simple, steady state groundwater flow systems where hydrogeological conditions can be clearly and confidently defined. Such conditions are rare, particularly in Canada where the glacial sediments frequently result in geometrically complex, multi-layer aquifer systems (e.g. Martin and Frind, 1998). In most cases, classification schemes represent an over-simplification of the groundwater system at best, and provide a recipe for misinterpretation and abuse at their worst. They are particularly dangerous when used by individuals with limited hydrogeological knowledge and experience.

At the University of Toronto, groundwater protection measures based on "standards of practice" have been rejected in favour of a quantitative "standards of performance" approach to impact assessment. Enforced at the Provincial level of government, performance standards would provide protection for quality and quantity by designating limits to which changes in land use practice are allowed to impact an aquifer. The onus would be put on the proponent of the land use change to perform the necessary sub-surface investigations and provide designs, monitoring programs and contingency plans that would ensure the environmental guidelines will be met for met for all time. Importantly, the "standards of performance" approach must not simply be limited to residential subdivisions, a relatively innocuous component of an urbanised region from the standpoint of water quality and quantity degradation. To be effective, it is essential that the protection measures be invoked for all urban infrastructure, without exception. This includes shopping malls, arterial roads, gasoline stations, parks, and even golf courses.

From a quantity perspective, and in the case of urban development, it is believed that the standard should require total aquifer recharge (direct plus indirect) be maintained on a sub-watershed basis at pre-development levels. Where necessary this may require the use of soakaway pits and rapid infiltration basins (RIBs) to replace lost recharge. From a water quality perspective, it is proposed that the "Reasonable Use Guidelines" (MOE, 1994), presently used in Ontario to regulate the design of domestic landfills be adopted and modified as appropriate. Essentially these guidelines (Howard et al., 1996) recognize that all landfills must ultimately cause some impact on subsurface water quality, and therefore establishes limits of degradation, which must not be exceeded beyond the site boundary for all time. Typically, these limits are set for individual contaminating chemicals at between 25 and 50% of the drinking water quality standard. Where landfills overlie major aquifers, the dilution of leachate by fresh groundwater moving in the underlying aquifer can play a major role in allowing these standards to be met. In the case of urban development, it is considered less appropriate to rely on dilution to attenuate introduced contaminants to the appropriate levels. Instead, it is proposed that the reasonable use guidelines be modified to require that the performance standards be met, not at the site boundary, but in the recharge water as averaged over the site. Under this scenario, the risk of cumulative degradation due to development on adjacent sites is avoided. As an example, for an urban subdivision where groundwater recharge averages 100 mm per year, it would be necessary to limit the annual use of NaCl road de-icing chemicals to approximately 20 tonnes (12.5 tonnes chloride) per km^2 to meet a performance standard of 125 mg/l chloride in the recharge.

CONCLUSION

Metropolitan Toronto faces a problem common to many cities worldwide - rapid urban growth with serious questions being asked as to its environmental sustainability and the potential impacts on the quality and quantity of water resources. Recent studies undertaken at the University of Toronto confirm that while residential sub-divisions are relatively innocuous components of a heavily urbanised region, urban infrastructure including shopping malls, arterial roads, gasoline stations, parks and golf courses can pose a serious threat to the quality and quantity of groundwater. While Federal, Provincial and Municipal laws exist that may limit impacts, this legislation is complex, limited in extent, and rarely acknowledges either the wide range of potential urban contaminants or the temporal dynamics of groundwater flow.

For many Canadians, the perceived abundance of fresh water resources has led to widespread complacency. While there is some awareness for surface water issues, very few Canadians rank groundwater protection as a priority concern. Matters seemed to have changed somewhat in recent months with many southern Ontario residents enraged by proposals to develop parts of the Oak Ridges Moraine, a major aquifer. The resulting campaign to "Save the Moraine", spearheaded by citizens' groups and spurred by the media has become highly political, preferring to ignore scientific evidence showing that responsible sub-division design can negate impacts on water. Nevertheless, the movement has at least served to bring groundwater issues to the public's attention and highlight the archaic state of existing legislation for groundwater protection in the province.

In the case of urban ground water, existing laws for the protection of urban water resources in Ontario and much of Canada are essentially impotent. For the most part, the Ontario legislation is little more than a patchwork of statutes, policies, programs, regulations and guidelines which lack the breadth, versatility and conviction to deal with the wide range of potential urban contaminants and the dynamics of groundwater flow within frequently complex glacial aquifer systems. A key problem is that there is no department at any level of government, that appears willing or, for that matter, capable of taking responsibility for the management and protection of Canada's groundwater resources.

Ontario, indeed, Canada as a whole, urgently needs a broad, and scientifically based policy that will provide Protection and Management for all ground and surface water. Research and experience suggest that such a policy should be based on standards of performance approach, and be policed at the provincial level. Standards would designate limits for the degree to which a change in land use would be allowed to degrade water quality, and may also require that total recharge remain unaltered on a sub-watershed basis. This type of approach would show respect for local hydrogeological conditions and encourage planning innovation. The approach would also encumber the proponent of land use change with the responsibility to perform appropriate sub-surface investigations and provide designs, monitoring programs and contingency plans that would enable environmental standards to be met for all time.

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5. Groundwater Issues in Planning

Padraig Thornton, An Bord Pleanala

GROUNDWATER ISSUES IN PLANNING

Padraic Thornton (Senior Planning Inspector, An Bord Pleanála)

Abstract

Land use planning can be used as a method of protecting groundwaters. Development proposals which involve interference with existing land uses by interfering with the water supply serving such uses are also of concern to the land use planning process.

This paper sets out the legal framework in which the land use planning system operates in so far as this is of relevance to groundwater issues. The paper examines the issues of concern from a land use/planning point of view, refers to strengths and weaknesses of the existing system and highlights areas in need of review.

Introduction

Land use planning is a dynamic process with social, economic and environmental interests and impacts influencing to varying degrees the use of land and water (Groundwater Protection Schemes, DoELG/EPA/GSI publication).

Groundwater in most parts of Ireland is a resource which is vital to the proper planning and sustainable development of the area. It facilitates development by its direct use for domestic, industrial, agricultural and commercial purposes. It also contributes significantly to surface waters which similarly facilitate development and also have significant amenity value.

Land uses impact to varying degrees on environmental media including the aquatic environment. Land uses can significantly impact on groundwaters and groundwaters can be used to support various land uses. This paper examines issues relating to groundwater which arise in land use planning.

Legal Context and Framework

The purpose of land use planning as set out in the Local Government (Planning and Development) Act, 1963 is, inter alia, to make provision, in the interests of the common good, for the proper planning and development of cities, towns and other areas whether urban or rural (including the preservation and improvement of the amenities thereof).

Development Plans are formulated and adopted and development control is implemented having regard to this essential purpose of land use planning legislation.

Each planning authority is obliged to make a Development Plan and this Plan must be reviewed at least every five years. The adoption of the Development Plan is a reserved function of the elected members. A planning authority is required to indicate development objectives for its area in the Development Plan. The legislation sets out some specific objectives which must be included in Development Plans. Objectives which must be included in Plans for urban areas which may be of relevance in terms of groundwater are objectives

(a) for preserving and improving and extending amenities and
(b) for the conservation and protection of European sites in the area to which the Development Plan relates.

Development objectives which must be included in Development Plans for rural areas include

(a) objectives for preserving and improving and extending amenities
(b) objectives for the provision of new water supplies and sewerage services and the extension of existing such services and

(c) objectives for the conservation and protection of European sites in the area to which the Development Plan relates.

The Development Plan may also indicate objectives for any of the purposes mentioned in the Third Schedule of the 1963 Act. Included in the Third Schedule as purposes for which objectives may be included are

(a) regulating and controlling the provision of water supplies, sewers and drains.
(b) determining the provision and siting of sanitary services and
(c) prohibiting, regulating or controlling the deposit or disposal of waste material and refuse, the disposal of sewage and the pollution of rivers, lakes, ponds, gullies and the seashore.

(Groundwater is not specifically referred to)

In determining planning applications the planning authority and An Bord Pleanála is restricted to considering the proper planning and development of the area of the authority (including the preservation and improvement of the amenities thereof) regard being had to the provisions of the Development Plan, the provisions of any Special Amenity Area Order relating to the area and other matters set out in the legislation in relation to which the planning authority may impose conditions. (The conditions listed do not relate specifically to groundwater or indeed pollution of waters in general).

The planning authority may not grant planning permission for development which would materially contravene a Development Plan except in accordance with a complex procedure requiring support for the proposal from a significant majority of the elected members (not less than 75% of the members of the planning authority must vote in favour of the proposal.) An Bord Pleanála, however, although it must have regard to the Development Plan is not bound to the same extent as the planning authority.

On receipt of a planning application the planning authority or the Board on appeal may refuse planning permission or grant planning permission with or without conditions. Under planning legislation certain reasons for refusal and the imposition of certain conditions do not give rise to the payment of compensation. The current situation in relation to compensation is set out in the Local Government (Planing and Development) Act, 1990. Non-compensation reasons for refusal are set out in the Third Schedule of the Act. Amongst the reasons listed are that any structure or addition or extension to a structure would be prejudicial to public health and that the proposed development would cause serious air pollution, water pollution, noise pollution or vibration or pollution connected with the disposal of waste. Conditions which may be imposed and which do not give rise to compensation are listed in the Fourth Schedule. The list includes any condition in relation to the provision and siting of sanitary services and recreational facilities, any condition relating tp the filling of land and any condition prohibiting, regulating or controlling the deposit or disposal of waste materials and refuse, the disposal of sewage and the pollution of rivers, lakes, ponds, gullies and the seashore. (There is no specific reference to groundwater.)

Legislative changes proposed in the Local Government (Planning and Development) Bill, 1999 which are of some relevance in relation to the issue of groundwater protection includes the change in the phrase "the proper planning and development of the area" to "the proper planning and sustainable development of the area" in both the stated purpose of the Act and the limitation on the issues to which the planning authority may have regard in considering an application for planning permission. It is proposed to add to the lists of objectives which may be included in a Development Plan. One of the additions refers to prohibiting, regulating or controlling the pollution of waters. (This would include groundwater). It is also proposed to add any condition relating to the pollution and conservation of the environment to the list of conditions which would be non-compensatable. The wording refers, inter alia, to groundwater.

It has been held in the High Court in 1975 (Frescati Estates V Walker) that an application for planning permission to be valid must be made either by or with the approval of a person who is able to assert sufficient legal estate or interest to enable him to carry out the proposed development or so much of the proposed development as relate to the property in question. It has been contested that in situations where a development involves interference with the water table e.g. by lowering the water table beneath lands not under the control of the applicant and without the consent of the land owner there is no valid planning application. The judgement of the Supreme Court (Mr. Justice Egan) in the case of Scott V An Bord Pleanála and Arcon was that development "must be construed as meaning the carrying out of works on land and not merely the consequences of these works on other lands". The consent of persons who own lands beneath which the water table may be effected is accordingly not required for a valid planning application.

The Development Plan

The Development Plan is a very important document in the context of controlling land uses and determining whether planning permission should be granted for a particular development. In this regard I consider that if groundwater is to be adequately protected it is desirable that where a Groundwater Protection Scheme has been drawn up and adopted by a local authority the scheme should be incorporated into the Development Plan. The full protection scheme may form an appendix to the Development Plan. I consider that policies in the Development Plan which relate to issues which have the potential to impact of groundwater e.g. locational policies in relation to housing in unserviced areas, landfills and intensive agricultural developments should have regard to and refer to the Groundwater Protection Scheme and in particular the land surface zoning or groundwater protection zones referred to in the schemes. I consider that groundwater protection schemes should be used in determining the appropriateness of proposed land uses in addition to being used in accessing licence applications for point discharges. If the groundwater protection scheme is incorporated into the Development Plan I consider that it would considerably strengthen general policies in the Plan in relation to the prevention of water pollution.

I consider that it is desirable that some research be undertaken as to how the groundwater protection schemes might be incorporated in some detail into Development Plans. Some recent Development Plans e.g. County Waterford have attempted to incorporate the Groundwater Protection Scheme. There is a statement in the Plan that "it is the policy of the Council to have regard to the Groundwater Protection Plan in assessing development proposals in County Waterford". This gives added status to the Protection Scheme in terms of it use as a tool in development control. The value of the schemes are somewhat restricted however as groundwater protection responses have as yet been adopted only for landspreading of organic wastes and landfills. It is doubtful if responses or codes of practice adopted after the adoption of the Development Plan can be considered to be part of the Development Plan.

EIA Directive and Planning Control

The EU Environmental Impact Assessment Directive is implemented through the planning process for most private developments. The impact of developments on groundwater must be considered as part of the development control process for developments for which an EIS is required. The preamble to Council Directive 97/11 EC states that the European Community policy on the environment is based on the precautionary principle, on the principles that preventative action should be taken and that environmental damage should as a priority be rectified at source and that the polluter should pay.

The polices and principles referred to above are incorporated into Irish policies on the environment and environmental protection. The planning system operates on the basis of these policies particularly in relation to major development where the potential for significant impact on the environment is greatest. The planning system however has not been adopted to provide for full implementation of the polluter pays principle except to the extent that contributions may be sought in planning decisions for works to be carried out by the local authority which will facilitate the proposed development. The principle however is implemented through other aspects of the legislation e.g. the Water Pollution acts. The subdivision of responsibilities between the Environmental Protection Agency and the planning system also gives rise to some difficulties for the planning system due to limitation on the issues which can be considered in the planning code. e.g. environmental pollution matters cannot be considered in the planning control system when a licence from the EPA is required. This issue will be discussed later.

Limitations and Weaknesses

Whilst the planning code has a significant role to play in protecting the groundwater resource, there are limitations in the extent to which the planning code can ensure the long term protection of groundwaters. The planning code can be used to prevent land uses which would endanger groundwaters and to control proposed land uses by the provision of suitable drainage facilities etc to prevent groundwater pollution. The planning code of itself however would not be an adequate protection for groundwaters as many activities and developments e.g. existing developments and "exempted developments" do not come within planning control. There is provision in planning legislation for requiring the discontinuance of a land use (Section 37 of the Local Government (Planning and Development) Act, 1963). This Section however has seldom, if ever, been used.

Section 4(1)(a) of the Local Government (Planning and Development) Act, 1963 exempts from planning control development consisting of the use of any land for the purposes of agriculture or forestry including afforestation and development consisting of the use for any of these purposes of any building occupied together with land so used. With the introduction of the Environmental Impact Assessment procedure some agricultural and forestry developments have been brought within the scope of planning control and the usual exemption no longer applies to such development. Normal agricultural activities however are generally exempted from planning control. Many agricultural structures are also exempted from planning control by regulations. Activities which involve the use of sheep dips, pesticides, insecticides, inorganic fertilisers and organic fertilisers except that arising from developments which are not exempted under exempted development regulations are not controlled by the planning system.

In cases where an IPC license in required from the Environmental Protection Agency, the planning control system can no longer be relied upon to exclude uses which would give rise to a danger of the pollution of groundwaters. This situation arises from Section 98 of the Environmental Protection Agency Act 1992. This Section prohibits the planning authority or An Bord Pleanála from considering "environmental pollution" arising from the activity when considering a planning application for a development for which a licence is required. A similar exclusion applies in the case of activities for which a licence is required under the Waste Management Act, 1996. Section 54 of the Waste Management Act applies in this regard. The exclusion from considering "environmental pollution" matters in the planning code has considerably reduced the ability of the planning control system to ensure that developments permitted do not give rise to the risk to pollution of groundwaters. An example of a case where such a situation arose was a proposal for the construction of additional pig housing at an existing pig unit at Annestown, Killeagh, County Cork. Cork County Council decided to refuse planning permission on the basis that the proposed development would be likely to have a major detrimental effect on the public infrastructural facility which the public water supply using a groundwater source provides and would thereby be prejudicial to public health and contrary to the proper planning and development of the area. The Planning Appeals Board concluded that it was precluded from refusing permission for the proposed development for the reason given by the planning authority. The Board concluded that the reason came within the scope of the definition of "environmental pollution" given in Section 4 of the Environmental Protection Agency Act. Planning permission subject to conditions was granted. In the First Schedule to the decision it was stated that having regard to matters other than the risk of environmental pollution, in accordance with the provisions of Section 98 of the Environmental Protection Agency Act and taking into account the pattern of land use in the area and the established use of a piggery on the site it was considered that subject to the conditions imposed the proposed development would not be contrary to the proper planning and development of the area.

Since the coming into operation of the IPC licensing system under the Environmental Protection Agency Act, 1992 and the waste licensing system under the Waste Management Act, 1996 the impact of the planning code in terms of preventing groundwater pollution has been considerably weakened. Proposed amendments contained in the Local Government (Planning and Development) Bill, 1999 aim at re-addressing the relationship between the planning code and the licensing system in order to ensure that inappropriate land uses would not be granted planning permission. It remains to be seen whether or not the proposed amendments will be passed into law and if so how the modified system will operate.

Issues Other Than Pollution

The threat of pollution of groundwaters is not the only aspect in relation to groundwater which arises in considering planning applications. The planning system also takes account of the impact of proposed developments on water supplies derived from groundwater resources. The lowering of the water table with consequential impact on wells and bore holes serving existing developments is a relevant planning consideration. The planning system also has regard to the potential impact on the stability of structures in the vicinity in the event of the water table being lowered in situations where foundations of adjoining properties may be located on sand, gravel or fill material. In the planning permission granted by An Bord Pleanála for the Galmoy zinc and lead mine conditions 13 to 21 dealt the issue of water supply replacement. The question of interference with the groundwater supply, in so far as this impacts on other established land uses in an area is a relevant planning consideration. This remains so even having regard to Section 98 of the Environmental Protection Agency Act. In its decision on a proposed cement factory in the Kilkelly area in County Mayo, An Bord Pleanála referred to the lack of evidence and the lack of detail submitted in the EIS in relation to the impact of dewatering of the site. This decision related to a case where the Board was excluded from considering the environmental pollution issues arising from the licensable activity. (Decision date 27th May, 1999) The potential impact on the structural stability of adjoining properties, due to groundwater lowering, is also a relevant planning consideration. This issue arose in the proposal to redevelop the gasometer or former gas storage site at Barrow Street. Questions arose in relation to the stability of a railway embankment and adjoining properties.

Discussion

SR6:1991 is not almost 10 years old and is due to be replaced (hopefully) by a document dealing with waste water treatment plants in general. There is still a great variation in the practices of planning authorities in so far as the requirement to carry out soil percolation and water table tests is concerned. In some local authorities such tests are requested as a normal part of the process. In others they are seldom requested. There appears to be no general consistency throughout the country or even within a particular county in some cases. There is also a lack of guidance in terms of compliance with groundwater protection schemes due to the fact that responses for waste water treatment systems have not yet been adopted.

When inspecting sites the potential impact on groundwaters is generally less obvious than the potential impact on surface waters. It is generally easier to discern whether the soil has a low percolation rate rather than having a fast percolation rate and poor attenuation capacity. Significant difficulties can arise in the absence of trial holes and soil percolation tests. An added complication arises at appeal stage in that trial holes which were excavated at the time of the original application have often been closed in and are not available for inspection at the time when the appeal is being determined. Plans submitted are often lacking in detail in relation to the location of wells in the vicinity of sites. Detailed information in relation to depth of wells and more detailed hydogeological information e.g. depth of soil above bed rock or water table is seldom available. In the case of agricultural developments e.g. those for which an IPC licence is not required and the environmental pollution issues may be considered under the planning code, basic information such as depth to bed rock or depth to water table is often not available. Even a relatively small farmyard has potential for pollution considerably in excess of that likely to arise from a septic tank. The need for more detailed information in relation to agricultural developments does not appear to be appreciated in the absence of the equivalent of SR6:1991 for such developments.

A significant problem facing planning authorities currently relates to the acceptability of small proprietary effluent treatment systems as an alternative to septic tanks on sites which fail the SR6:1991 tests for septic tank and percolation area suitability. Such facilities are now proposed as a panacea for all difficulties. The question of the final disposal of treated effluent or partially treated effluent is generally proposed to be resolved by the construction of overground percolation areas. Most planning authorities are insufficiently staffed to monitor and ensure compliance with detailed conditions which may be imposed in relation to the construction of such percolation areas. I consider that more detailed guidelines in the form of a review of SR6:1991 to take account of the various proprietary effluent treatment systems available are required urgently. The question of the disposal of treated effluent needs to be specifically addressed.

6.* Planning & Groundwater Supply

Fergus Coyle, Monaghan County Council

7. Groundwater in the Courts or Common Logic vs. Hydrogeological Concepts

Kevin Cullen P.Geo., K.T. Cullen & Co. Ltd.

Groundwater In The Courts

or

Common Logic v. Hydrogeological Concepts

By

Kevin T. Cullen P.Geo.

A Paper Presented To The IAH-Irish Group, 11 & 12-April 2000

1. Introduction

In 1982, a High Court case between two Limerick farmers involving the pollution of a well introduced hydrogeological concepts to the Irish courts for the first time. In his reserved judgement, Judge Costello found in favour of the Plaintiff, Mr. Berkery and in doing so clearly indicated that arguing a case on purely hydrogeological concepts would not by themselves win against basic observations even where the related deductions were a theoretical impossibility.

The judgement, as printed in the Limerick Leader of 10-July 1982 is reproduced here. The judgement provides a clear warning to hydrogeologists that while groundwater is known to follow the natural laws of physics the fact that it remains mostly hidden from view allows different deductions from a single set of observations.

Examine the evidence as presented in Judge Costello's excellent summary and arrive at your own conclusions.

2. Abstract From The Limerick Leader (10 July 1982)

High Court Restricts use of Limerick Farm

A County Limerick dairy farmer has been ordered by the High Court to restrict the number of animals to be kept on his farm, and preventing him from using an outwintering unit on his holdings, because of polluting effects on the water supply on a neighbouring farm.

Seven injunctions restricting the use of the lands and requiring the defendant to take immediate steps to prevent further pollution were made in the High Court, Dublin on Monday, following an award of £4,500 damages and costs in favour of the plaintiff.

The action was brought by Mr. James Berkery, Knocksouna, Kilmallock, against Mr. Henry Flynn, Knocksouna, Kilmallock.

Plaintiff claimed that a "spring" water supply on his farm used for domestic and farm supply was contaminated by silage and slurry effluent from the farm of the defendant located over 500 yards away.

Mr. Peter Sutherland, S.C., Mr. Brian McCracken, S.C., and Mr. Peter Kelly B. L. instructed by Messrs. Maurice M. Power & Son, solicitors, Kilmallock, appeared for the plaintiff.

Mr. Ralph Sutton, S.C., Mr. Richard Johnston S.C., and Mr. Gerald Tynan, B.L., instructed by Messrs. Wm Lee & Sons, solicitors, Kilmallock represented the defendant.

The hearing, which lasted for two weeks was told that the area between the two sources comprised of a hill of limestone rock and that silage effluent had been found in the well shortly after the crop had been ensiled on the defendant's farm.

Air

A geologist gave evidence of carrying out a visual assessment of the area from the air.

The defendant pleaded that the contamination was caused by some other source because of the difficulty in linking the well with the farm effluent which was over 500 yards away.

In a reserved judgement, Mr. Justice Costello found in favour of the plaintiff.

He said that the slurry storage facilities on the farm were inadequate for the number of livestock kept both at the farmyard and an outwintering unit on the farm.

Justice Costello stated " I am quite satisfied that although he obtained a grant from the Department in relation to the disposal system he installed, his work was not supervised and the size of the tank was determined by the defendant himself and is not in accordance with the departments requirements".

The High Court granted the following injunctions, with liberty to the defendant to apply to the court in the event of breach of the orders.

An injunction restraining defendant by himself or his agents from causing, permitting or allowing effluent from a slurry, or other deliterious substances escaping into or polluting an underground flow or system of water so that drawn from a well situated on the plaintiffs land at Knocksouna, Kilmallock is rendered impure and contaminated to such an extent to be unfit for drinking by humans and livestock and unfit for use by the plaintiff for his domestic purposed and for use by him in carrying on his farming on the said lands.

Slurry

An injunction requiring defendant to make adequate provision or the collection of slurry and other effluent arising from the defendants farm at Knocksouna, Kilmallock and to make adequate provision for the storage and disposal in such a manner as to prevent same from fouling or contaminating or polluting an underground flow or system of water underneath his said lands to such an extent that it contaminated and renders water drawn from the plaintiffs well unfit for drinking by humans and livestock and unfit for use by the plaintiff for domestic purposes and for the purpose of his said farm.

An injunction restraining defendant from maintaining silage or from feeding cattle on his out winter unit and also restraining the use of the said lands in that area.

An injunction to restrain the defendants use of his outbuildings for the housing of cattle to not more than 103 animals. The purposes not to be subject to this injunction.

An injunction to restrain the defendants use of his outbuildings for the housing of cattle to not more than 103 animals. The milking parlour for milking purposes not be subject to this injunction.

An injunction requiring defendant to keep the channels in the vicinity of his dungstead from any matter which would permit the channels to overflow.

An injunction to take effect three months from July 5, 1982 restraining the use of the outbuildings for the housing of cattle unless a soiled water tank is installed with the capacity to service 103 cattle in said outbuildings the dimensions of the said tank to be approved by Dr. Dodd.

Notice

An injunction requiring the defendant to permit the inspection from time to time, on 24 hours notice by the plaintiff or his agent dungstead and outwintering unit to enable him to confirm compliance with the orders.

Judgements

Mr. Justice Costello in his judgement said:- "The plaintiff owns and occupies a firm of about 155 acres at Knocksona not far from not far from Kilmallock in the County of Limerick where he lives with his wife and family and on which he has carried on a successful dairy farming business. His claim is that the defendant has polluted a well from which he derives a water supply which he uses both for domestic purposes and for his farming business.

"He instituted these proceedings on the 27th July 1980 claiming injunctive relief and damages and on the 30th of July obtained an interlocutory order which was to remain in force pending the trial of the action. The defendant is the owner an occupier of a neighbouring farm on which he too engages in diary farming.

The Planitiff's case is that the defendant erected a slurry pit in the farm-yard in the winter of 1976/77 and that the overflow from this slurry pit has been a source of pollution because it entered the groundwater system which feeds his well.

A second source of pollution has been the plaintiff says, an outwintering unit on the Defendant's lands on which large amounts of slurry accumulated in the winter months and from which pollutants enter the same groundwater system.

These allegations are strenuously denied by the Defendant who has called expert evidence to establish that neither the overflow from the slurry pit or from the outwintering unit could possibly have contaminated the well.

Intense

" The debate between the geologists has been intense, the areas of disagreement between them very large, and their conclusions diametrically opposed. As in other cases in which experts disagree I must examine the facts of this case in some detail to see what assistance can be derived from them in resolving the technical aspects of the case.

"I propose, therefore, to begin this judgement by examining the evidence relating to the pollution of the Plaintiffs well. I will turn then to the operations carried on by the Defendant of which complaint is made; and finally I will consider the geological evidence adduced by the parties"

Referring to the pollution of the plaintiffs well he continued: "The Plaintiffs well (which can more accurately be called a spring) is situated in a large field which has been divided into three parts by the Plaintiff by means of wire fencing. It is not far from the Loobagh River which forms one part of the boundary of the large field to which I have referred. The field slopes upwards towards Knocksouna hill.

"In a direction roughly westwards of the well the Defendants farm buildings are situated. These comprise houses and feeding facilities for a dairy herd, a milking parlour, calving down pens, and calf housing. Manure is stored in an over ground tank referred to sometime as a 'slurry pit' and sometimes as a 'dungstead'. The slurry pit is 48 feet wide and 63 feet long with an average depth of 4 feet.

Opening

"There is an opening at the rear of it which is closed by means of railway sleepers whose purpose is to allow drainage from the tank into the channels surrounding the pit. There is a soiled water tank of an estimated capacity of 330 gallons and water which is used to clean out the farm-yard buildings and farm-yard travels in channels and drains into the soiled water tank, as does seepage from the slurry pit through the sleepers.

"The contents soiled water tank are pumped through a movable pipe to different parts of the Defendant's land. The yard is on elevated ground and the slurry pit is in fact about 50 feet above the level of the bottom of the Plaintiffs well and 533 yards from it.

"The outwintering unit on the Defendant's land is closer to the Plaintiff's well. It comprises a concrete slab on which silage is made and on which cattle congregate at feeding units. The capacity of this slab is about 250 tons. The stock feed at the face of the silage and also from silage bins located on the feeding area.

The feeding area is cleaned by a scraper mounted on a tractor. There is an unlined earth wall manure storage area, referred to as a lagoon. This slurry lagoon has no formal drainage facilities and combination of evaporation and drainage into the ground or through the banks of the lagoon. The lagoon is about 260 yards from the Plaintiff's well and about 60 feet above it.

Supply

"The Plaintiff has carried on a dairy farming business on his farm for about 20 years and for the past 18 years or so has used the well as a water supply. He began by using it to water his lands and extended its use each year. He installed an electric pump in a small pumping house beside the well and from this water was pumped to his dwelling and milking parlours. In addition water from the well is piped to troughs on his fields and at present he has about 17 troughs throughout his farm. His herd comprises between 68 to 72 cows and about 30 heifers. He is a pedigree breeder and has won many awards.

"His wintering season for his cows is from about the 1st April each year and that for his younger cattle from the 1st December to the 1st of April. He has no outwintering unit and during his winter season his cattle are kept indoors. The field in which the well is situated is a large 30 acre field divided, as I have said, by electric fencing.

"There is now a fencing area of about one and a half acres in the vicinity of the well. He grazes about four to five cattle in the vicinity of the well, but not continuously, in the summer season. It is a feature of some significance in this case that during the winter season there are no cattle in the large field or near the well and in the summer months there are no cattle in it's vicinity between the 1st of August and the end of September.

"The pumphouse and well are surrounded by an electric fence which the plaintiff built in the early autumn if 1978".

He continued: "The first time that the plaintiff was troubled with pollution was the summer of 1978. He then for the first time noticed that the water from the taps was dirty in his milking parlour as well as in his dwelling house and it smelled of stale cattle manure.

"So he stopped using the water supply immediately and had to draw water from a neighbour. But the pollution continued and he noticed that the condition of his water was associated with the weather – if there was a dry spell the condition cleared up but after heavy rain the water supply again became polluted.

"At this time there were long periods when conditions were normal and the Plaintiff hoped that the problem would clear itself. He did not know what the cause of the trouble was but took the precaution of putting an electric fence around his well in case his own cattle were responsible.

"The condition, however, got much worse in the winter of 1978/79 even though he had no cattle on his land from the beginning of December 1978 and pollution continued throughout 1979 into the year 1980.

During this period the Plaintiff obtained water from a neighbour and also from his local co-operative.

Rain

"Matters came to a head in the summer of 1980. On the 1st June of that year after a period of heavy rain the Plaintiff experienced a "terrible foul smelling odour" from the water. It was he said the worst he had ever experienced.

He described the smell as a mixture of stale slurry and silage and although questioned closely on the matter he remained adamant that the water smelt of silage. He stated that he knew that the Defendant had made silage on the 22nd May previously because he had seen the machine in the Defendant' field, and that he nor his neighbour had made silage at that time.

"As the bad smell continued he decided to go and see the Defendant about the matter as he began to suspect that the Defendant might be responsible for what was happening. Silage, he explained is cut and put into a shed where it is pressed down and rolled by means of a tractor.

"The juices from the cut grass are forced out and would flow into the Defendant's yard for perhaps six to eight weeks after the silage was originally cut.

Visit

On the 3rd Sunday in June, the 15th of the month, the plaintiff visited the Defendant. He again visited him on the following Tuesday.

There is some difference of recollection between the parties as to what occurred and I am satisfied that the Plaintiff version is the correct one. He explained to the Defendant that his well was polluted with silage and slurry and that he believed that the pollution must be coming from the Defendant's yard because he was the only person making silage in the neighbourhood.

Having initially taken up a somewhat belligerent attitude to the Plaintiff (because he had crossed uninvited into his lands) the Defendant then adopted a more reasonable stance. He referred to the fact that he knew about the problem of pollution as he had inadvertently polluted his own well and he then walked to his slurry pit with the plaintiff.

The plaintiff noticed that the channels around the railway sleepers at the rare of the slurry pit were choked with weeds and solid slurry and that the land at the back of the slurry pit was like a quagmire and he could see that fluid from the slurry was not able to flow into the channels, and he pointed out these conditions to the Defendant and suggested that they could be the source of pollution.

Disagreed

"The Defendant would not agree, but in the course of their discussion he commented that the slurry pit had not been a success.

The plaintiff remembered that on a previous occasion the Defendant had said to him and to other farmers were looking at his new disposal system that in normal conditions it was a good job but that in heavy rain there would be an overflow, and he suggested to the Defendant that he might consider getting a bigger tank to catch the overflow and pump it out from time to time.

The Defendant agreed to do the best he could to stop the spread of the silage and the slurry over the ground and the Plaintiff explained to him that he had got no advice about the matter and he thought would be best if it could be settled between them on a man to man basis.

On the following Tuesday the plaintiff called again to the defendant. He saw that the slurry pit and noticed that the defendant had cut some of the weeds and had made some attempt to sweep the channel.

Abusive

But when he met the Defendant the Defendant was very abusive, apparently because the plaintiff had entered the lands and viewed the slurry pit without the Defendant's permission. He refused to come to look at the slurry pit or to visit the Plaintiff's house to see the pollution and adopted the attitude that if the Plaintiff though that he was polluting his well the Plaintiff would have to prove it.

"And so matters were put in train which have led to this hearing. Two days after their meeting the Plaintiff consulted his Solicitor and after obtaining advice on the matter from an engineer, Mr. Brennan, the Plaintiff's Solicitor wrote on the 15th July 1980 formally complaining that the Defendant was responsible for the pollution of the Plaintiffs water supply.

The Defendant's Solicitor replied on the 18th July denying the allegation and stated that "our client has had comprehensive geological and scientific surveys carried out". This was a considerable exaggerated of the quality of the advice the Defendant had obtained; he had, in fact, consulted two water diviners (one of whom divided water by looking at a map) and neither of whom gave evidence at the hearing.

"On the 30th of July I made an order against the Defendant to restrain the acts of nuisance complained of until the trial of the action".

Justice Costello continued: "There was an improvement in the conditions of the Plaintiff's water in the month of August, 1980 during a spell of fine weather, but on the 10th of October serious pollution occurrence again.

"This time the Plaintiff was quite satisfied that there was no smell of silage but the water contained a smell of stale cattle slurry. After that every time there has been heavy rain pollution occurred. Visually the water was dirty and this remained the situation during the winter of 1980.

In the winter the Plaintiff, as usual, took all his cows off the land on the 10th November, leaving 15 heifers outdoors until the 1st of December not, however, in the paddock where the well was situated but further up the hill.

During the spring and summer of 1981 conditions were more or less the same and the plaintiff has calculated that about 36 hours after heavy rain the pollution would be noticed in his kitchen. Similar conditions existed into the autumn of 1981.

Cattle

In the winter of 1981 the plaintiff noticed that there were much more cattle on the defendants outwintering unit and much more silage there than in previous years. After Christmas in 1981 the pattern of pollution changed.

From then the water has been dirty all the time, and the pollution obviously more serious. This is the situation at the present time, although the water shows some signs of improvement after long dry spells.

Before considering further the evidence relating to the pollution of the plaintiff's well there is one suggested source to which I should refer. The plaintiff was asked about the overflowing of the Loobagh river. I have no difficulty in accepting his evidence and concluding that this happens very rarely. When it does the overflow from the river does not go near the well. It lies below the well and in a situation where it could not possibly contaminate it.

I turn now to the evidence of Mr. Brennan, who is a civil engineer with considerable experience of advising clients in agriculture areas on water supply problems.

Inspection

He carried out his first inspection on the 26th of June 1980. He found that the water in the plaintiff's sink in his kitchen was foul-smelling and discoloured. He inspected the well and took photographs and found that the water in the well was polluted and had a foul smell.

H examined the ground around the plaintiffs well and wound that it was dry; there was no evidence of pollution from the plaintiffs own animals and no sign of animal manure in the area. There was, he could see, considerable outcropping of rock on Knocksouna Hill and Mr. Brennan concluded from his experience that the hill was a limestone hill.

From his knowledge of limestone and the ground water systems it can produce, he informed the view that the pollutant could have its origin on the hill. He drove the car to the defendant's farmyard and saw the slurry pit in the yard. He also saw the overflow from the slurry pit (which the plaintiff had seen a few days earlier) and noticed the wet manure on the ground at the rear of the slurry pit.

He returned on the 5th of July but there was no improvement in the pollution. The smell found in the water supply in the plaintiffs house was, he said, unpleasant - a really foul smell, which Mr. Brennan positively identified as a smell of silage. He advised that a geologist should be employed.

Doctor

On the 5th and 20th of November, 1980, Mr. Brennan visited the defendant's lands in the company of Doctor McCarthy, a geologist, whose evidence I will consider later.

Again he took photographs which show that at the time there was a very considerable overflow from the slurry pit and a very considerable accumulation of manure on the ground at the rear of the slurry pit. Significantly, Mr. Brennan noticed that although it was then only the beginning of the winter season the slurry pit was almost full.

On the 30th of June, 1981, he carried out a further inspection and took more photographs and established the difference in levels between the floor of the slurry pit and the bottom of the plaintiff's well.

Conditions had not changed; the channels surrounding the slurry pit were clogged with slurry and there was a seepage from the channel in the surrounding land. The sleepers in the top of the slurry pit were buckled (clearly to be seen in the photographs he took) and in danger of collapse and seepage through them could be observed. There was grass in the channels around the pit.

Engineer

His next visit was on the 25th of February 1982, with Doctor McCarthy and Doctor Dodd, an experienced agricultural engineer. The situation at the slurry pit was now very different. Work had recently been carried out on it and been laid at the rear where previously quagmire conditions had existed. All the surface manure had been removed, the channels were free and working and new sleepers had been put in. But the Plaintiff's well was still polluted and for the first time Mr. Brennan decided to have a look at the outwintering unit.

Mr. Brennan produced photographs which he took of this area. It was clear from these and from his evidence and the evidence of Doctor McCarthy and Doctor Dodd that the whole area at the outwintering unit was thickly coated with slurry and manure. The lagoon is unlined and very considerable quantities of slurry and manure would find their way into it.

Mr. Brennan's conclusion was that in June 1980 the overflow from the slurry pit must have been the cause of the pollution of the plaintiffs well, but that the continued pollution in February, 1982, had its source in the outwintering unit. He could find no other source which could have been the cause of the contamination from which the plaintiff suffered.

Dr. Dodd, as I said, is an engineer. He is on the staff of University College Dublin, and has specialised in water pollution control and in the handling and disposal of animal manures.

Evidence

I will return to his evidence later when considering the defendant's outbuilding and refer now to his evidence about his February 1983 inspection. He saw the plaintiff's well on the 25th of February. It was then visibly polluted and the well water contained suspended solids.

There were then no cattle in the plaintiff's field or anywhere in the vicinity of the well and there was no evidence of poaching of the ground and no evidence that it had recently been grazed. He visited the slurry pit and the outwintering unit. His opinion was that the lagoon would certainly leach, and the depth of the top soil in the area was negligible.

He saw an aquatic growth in a ditch in a southerly direction from the lagoon which divides the plaintiff's and the defendant's land and he thought that this growth could have been caused by septic conditions developing from the surface flow of effluent from the lagoon.

He considered that the most probably cause of the pollution in the plaintiff's well on the day of his visit was the outwintering unit (there being no overflow at the slurry pit) and he concluded that pollution could not have been caused by the plaintiff's own cattle.

Pollution

Evidence (which was not controverted) was given as to the nature of the pollution. Mr. Hickey of Golden Vale Co-Operative Creamery tested samples of water which were taken in July and October, 1980, and his conclusion was that the water was contaminated by some matter of faecal origin.

More detailed analyses were carried out and other samples taken by Mr. Healy, a chemist in the firm Consultus Limited. An analysis of samples taken on the 4th of July, 1980, showed the presence of faecal coliforms and he considered that the was heavily contaminated with faecal coliforms. Further analyses of water taken on the 23rd of March, 1981, and 15th of December, 1981, and the 8th March, 1982, produced the same results.

I am summarise, then, my conclusions relating to the pollution of the well as follows. It commenced in or about the summer of 1978.

At the beginning it was associated with heavy rain and usually became noticeable about 36 hours after such rainfall occurred. It was present not only in summer months when the plaintiff's cattle were on his land, but also during the winter months when they were indoors.

Summer

In the summer months it was present when there was no poaching in the vicinity of the well or other evidence to suggest that the well could have been contaminated by the plaintiff's own cattle. In the month of June, 1980, the pollution was associated with a distinctive smell of silage.

"Pollution got worse and became more continuous after Christmas 1981. As the well is polluted by faecal coliforms a form of bacteria derived from the intestines of animals, it is obvious that it is being polluted by animal slurry."

Referring to the defendant's activities, Mr. Justice Costello stated: "I turn now to the diary farming business carried on by the defendant. He started farming the lands in the year1968 and around that time he had a herd of between 35 to 40 cows. His practice at that time was to bring his herd into a shed in his farmyard after Christmas and place the manure from his herd on a dung heap in the farmyard. Over the years he expanded his herd and modernised his operations/

"In 1972 he started to develop the outwintering unit to which I have referred and built a concrete slab and dug a ditch and embankment to take the slurry from the feeding area. In the winter of that year he placed silage at the unit for the first time. He also began to build new outbuildings in his farmyard.

Shed

In December, 1973, he built a shed for calving, in 1974 kennels for his cows and in 1975 he concreted and area for the making of silage. In November, 1976, he began work on the slurry pit and completed it in January, 1977. In 1977 he provided more cubicles, and in 1979 another new shed and a double row of cubicles.

"As a result his herd is now accommodated in a building which combines a roofed silo with 24 cubicles for adult stock and 32 cubicles for young stock and a second building which contains a roofed silo and 72 cubicles for adult stock.

According to Dr. Dodd, the capacity of a building would normally be considered to be about 10 per cent more than the number of cubicles. This would mean that the defendant's buildings would be capable of housing about 105 adult stock and about 35 young stock.

I have already described the slurry tank. The soiled water tank from the farm buildings and the seepage from the slurry pit should drain has a capacity of only 330 gallons.

Capacity

"I accept Dr. Dodd's evidence that the recommended design capacity for a soiled water tank is 25 gallons per animal for dry stock and 50 gallons per cow place. On the basis of the capacity of the accommodation in the defendant's outbuildings the tank is clearly undersized.

"Indeed, the defendant does not seriously contest this evidence, and I am quite satisfied that, although he obtained a grant for the disposal system he installed, his work was not supervised and the size of the tank was determined by the defendant himself and is not in accordance with the Department's requirements.

In addition to the inadequate soiled water tank, I am satisfied that the slurry tank is also inadequate for the number of cattle which can be housed in the defendant's outbuildings. According to Dr. Dodd, it is normal to allow 1.5 square feet per cow per week when designing dungstead.

The justice went on: "If the winter period is taken at an average of 20 square feet per cow place would be required in the defendant's slurry pit. As the pit has a capacity of 3,080 square feet, this means that it has provision for about 103 cows only.

Slurry

"It follows that if the buildings are used to full capacity the slurry pit would be inadequate for its purpose. Dr. Dodd's opinion is supported by the evidence. Not only was the slurry pit nearly full in November, 1980, at the beginning of the winter period, but the defendant accepted that the slurry pit was inadequate for the number of animals he now has.

It is obvious the result of the inadequate slurry pit and an undersized spoiled water tank is that overflow conditions are likely to result.

As to the outwintering unit, the evidence shows that it was constructed in the year 1972, that the concrete area was extended in the year 1974, and that extra feeders were put in 1981. A greatly increase amount of silage was also put in the area in 1981.

Over the years the defendant has been increasing the size of his herd. The defendant's records show that at the end of the year 1972, his closing stock was 99 animals and that at the end of the year 1980 has closing stock was 141 animals. But these figures do not show the size of his stock at other times of the year and evidence from the defendant's notebook show that this stock was, in fact, much higher at other times.

Affidavit

"In an affidavit which he swore in July, 1980, he said he then had a 182 herd of cattle and at the present time he now has about 219 animals. Because his herd has increased he has had to take extra land in the vicinity for his own farm.

Significantly, his farm records show a considerable increase in silage in 1980, 53 acres as compared to 25 in the previous year.

As his herd increased accommodation in the outbuilding became inadequate and the defendant has had to increase the use of the outwintering unit. In the early day of his farming activities he used the unit only between November and January. But in the winter of 1980 he used it for a four month period, and in the year he had about 50 cattle on it.

Last winter he placed more silage on the outwintering unit than ever before and he agreed that in recent years he had double the number of cattle on it and has doubled the length of time they spend on it.

Source

"It was urged on the defendant's behalf that the defendant's farmyard could not possibly be a source of the pollution of the plaintiff's well because the contamination would have manifested itself before 1978 and would certainly have occurred prior to the erection of the slurry pit in the days. When manure was collected in an unprotected manure heap in the yard.

But the defendant evidence does not require me to draw such an inference. The defendant's business has been increasing over the years, and with it the size of his herd. The amount of manure to be disposed of has likewise increased.

The disposal system was changed in the winter of 1976/77 and quagmire conditions were created from the overflow of the slurry pit and surrounding channels.

These developments could explain why, the farmyard area is a re-charging zone for the plaintiff's spring, no pollution occurred prior to 1978. Similarly, I cannot draw any interference in the defendant's favour arising from the fact that the outwintering unit had been used since about the year 1972, as quiet clearly its use has been significantly increased over the years, particularly since 1980.

Conclusions

On the other hand, certain conclusions can be drawn from the evidence, which I have up to now suggest that the defendant is responsible for what has happened to the plaintiff's well. The well has since 1978 been polluted by animal slurry.

This pollution did not occur as a result of the overflow of the river Loobagh. It was not caused by the plaintiff's own cattle. In 1978 a slurry disposal system was introduced by the defendant which was inadequate for the increasing numbers of cattle in his herd and which overflow, causing slurry to accumulate in quagmire conditions behind the slurry tank.

In addition the use of the outwintering unit has been greatly increased since 1980 and massive quantities of slurry are stored in an unlined lagoon beside it. Furthermore in 1980 the plaintiff's well was polluted by silage at a time when no silage had been cut by him or his neighbours and at a time when the defendant had cut a greatly increased quantity of silage the juices from which would have been washed into the chocked channels around the slurry pit and have found their way into the overflow seen by the plaintiff and Mr. Brennan. No adequate steps to stop the overflow at the slurry tank were taken until after a committal motion was served on the defendant.

Facts

All the facts in the case support the plaintiff's claim. In that light I now turn to the geological evidence which was given on the parties behalf.

Turning to the geological evidence, Mr. Justice Costello said: "Dr. McCarthy, called on the plaintiff's behalf, is a highly qualified geologist presenting on the staff of University, College Cork. For the purpose of preparing his report and giving evidence he obtained aerial photographs of the area and he personally carried out a visual examination from the altitude of 500 feet above Knocksouna Hill.

He traversed the area on foot and examined the rock outcrops taking photographs of various geological features. In addition, he consulted the maps of the area in the Geological Survey of Ireland and searched the geological literature about the area. He visited on the 15th and 21st November, 1980, and again on the 25th of February 1982. His evidence was to the following effect.

As to the geographical setting and surface drainage, he found that the defendant's farmyard lies on the northern flank of the river Loobagh which is draining, broadly speaking, in a westerly direction.

Deposits

"The river is of a high standard sinuosity type and it continually reworks its own alluvial deposits. The trend of the deposits and of the river channel is the southwesterly detour which the river takes and which, in Dr. McCarthy's view, indicates the control of the river channel course by shallow bedrock extending southwards and south-eastwards below the surface of Knocksouna Hill.

"In his opinion, this fact strongly indicates that the cover of the superficial deposits capping the bedrock over the rising land to the north and northwest of the alluvial valley is thin. The Plaintiff's well is located to the southwest of the area close to the river at an altitude of approximately 205 feed O.D. and about 533 yards from the defendant's slurry pit overflow, which is at an altitude of about 250 feet O.D.

"There are no intervening valleys between the slurry pit and the well and the land surface rises progressively in a straight line from the well to the pit. Knocksouna Hill is a prominent feature of 338 feet O.D. and lies to the north of the line between the slurry pit and the well.

There is an abundance of rock outcrop on the hill area and along its southwestern flank.

There is a series of springs near the river. To the south of the slurry pit these were numbered on Figure 8, which the witnesses produced as S2 to S8.

Supplies

They have a temperature significantly higher than the water in the plaintiff's well and this indicates that they are not supplied from water in the immediate area, that they were in contact with the bed-rock and were part of a hot spring system unconnected with the plaintiff's well.

"Dr. McCarthy prepared a detailed map of the outcrop pattern (Figure 2) which showed the location of the surface rock exposures. The rock-bed (where rock was not visible on the surface) is over-lain by a cover of superficial deposits.

This drift cover is thin or absent at and around Knocksouna Hill and at and around the defendant's farmyard and slurry pit. The drift thickens southwards and south eastwards towards river and is accompanied by an increase in the depth to the bedrock surface.

The superficial deposits comprise (a) a thin organic soil cover and (b) a wedge of glacial deposits which are banked against the rising ground which descends below the alluvial deposits in the lower alluvial plane area and (c) sands and gravels in the alluvial plane.

Definite

"Dr McCarthy was quite definite that the bed-rock geology is composed of compact, well stratified, carboniferous, bioclastic limestones and that a characteristic feature of the limestone is the feature of the excellent development of bedding throughout the area which he claimed, rendered a preferred grain to the rock.

Typically he thought, the bedding planes are separated by an average of 20 cm. This part of his evidence was subject to considerable controversy and I will return to it later. He considered that the limestones were composed almost entirely of calcium carbonate with minor dolomite and siliceous levels.

He explained that the limestones were originally laid down in the form of horizontal sheets or beds and that subsequently these horizontal beds were subject to powerful horizontal north-south compressive stresses resulting in the development of east-west trending folds. The folds in the area of Knocksouna Hill were what is termed synclines, that is basin shaped troughs or inverted arches.

The axis of the syncline is orientated approximately east north-east/south southwest.

Axis

It plunges gently to the south/south-east: The beds to the north of the axis of the syncline, that is to say on the side of the axis nearest of the defendant's farm, are inclined downwards at angles are inclined downwards at angles up to 54 degrees to the horizontal, whilst in its axial zone the beds are inclined at less than ten degrees to the east north-east, that is parallel to the axis of the syncline.

Beds to the south of the synclinal axis are inclined towards the north. The result is that beds, which underlie the defendant's farmyard and the outwintering unit descend below the ground and are brought back to the surface on the southeastern flank of the syncline in the vicinity of the plaintiff's well – a phenomenon which he illustrated in the figures produced at the hearing.

The compressive forces which formed the folds also caused the development of a number of fractures in the rock – joint feature (i.e. closely spaced planer, clean fractures) as well as "fracture cleavage" (i.e. fractures which form a number of irregular features)

The limestone at and around Knocksouna Hill had developed a significant degree of porosity due to weathering and dissolution. In Doctor McCarthy's opinion by far the most significant and quantitatively important were solution cavities which had developed along the bedding plane.

Solution

However, in addition solution has also taken place along the joint fractures. There are of different types.

In Doctor McCarthy's opinion, the north-south striking joints to reach lower levels within the bedrock so that it can travel laterally between the sub-surface bedding planes and along the east-west striking joints – which are more gently inclined.

To reach conclusions about the groundwater flow from the defendant's slurry pit, Dr. McCarthy considered the evidence of the overflow which he saw on his first series of visits in November /December 1980.

This overflow was contained in a limited area and formed a quagmire. The ground beyond the quagmire was free of slurry and he concluded that there was considerable soakage from this quagmire into the underlying rock.

Water

The question which had to be determined was how the ground water would migrate from this area. Doctor McCarthy pointed out that rain water, polluted with the slurry in the overflow area, which entered the groundwater system would be controlled by (a) gravity and (b) the fracture pattern which he described.

He concluded that the groundwater flow would be controlled by the bedding and by the joint and cleavage solution, but tat the most important of these were the bedding cavities. The bedding cavities were so inclined that the groundwater below the slurry pit would migrate downhill along the bedding cavities in an easterly direction towards the plaintiff's well.

This migration would be facilitated by the north/south 'dipping' joints (i.e. the joints which are parallel to the dip of the beds) and by the east/west joint fractures which are parallel to axis of the syncline. The fractures were such that pollutants in the groundwater could be carried down to a succession of lower bedding planes and towards the plaintiff's well. The fractured bedrock, in Doctor McCarthy's opinion formed an aquifer which fed the plaintiff's well.

Doctor McCarthy pointed out (and on this there is no controversy) that the plaintiff's well is, in fact, a spring, that is to say a point at which the ground water is escaping to the surface under pressure. The spring is a permanent one and does not dry out even during dry conditions.

Reasons

For a number of reasons he considered that the groundwater flowing from the well did not come up-stream, that is to say from the east, and he concluded that the source of the groundwater from the well was from the northwest.

Because of the fracture trend to which he had referred, he considered that it could be concluded that part of the recharge zone to the plaintiff's well must lie at and around the defendant's slurry pit overflow. As a result pollutants soaking into the rock fractures at and below the overflow of the slurry pit would be incorporated into the groundwater system and would be transported to the well.

When Doctor McCarthy returned to the lands on the 25th of February 1982, the situation had considerably changed. As I have already pointed out, there was then no overflow at the slurry pit and so pollutants were not then entering the groundwater system from that source.

Doctor McCarthy, however, examined the outwintering unit and saw the large accumulation of slurry in the area and in the lagoon. He considered that the continued pollution of the plaintiff's well was due to the slurry entering the groundwater system from this point.

Bed-rock

The bedrock was exposed in the area and he considered that the slurry could circulate into the fractured bedrock without difficulty. Whilst some would flow on the surface of the ground towards the river, part of the slurry would go through the groundwater system he had described in an easterly direction towards the well.

The challenge to Doctor McCarthy's conclusions, which I will now examine, was given in the evidence for Mr. Connor and Mr. Cullen, two consultant hydrogeoloigists called on the defendant's behalf.

"Mr. O'Connor was first consulted in the autumn of 1980 and visited the area on 2nd of October, 1980, and carried out what he described later in an affidavit as an extensive survey of the defendant's land". He prepared a report arising from this survey and on the17th of December, 1980, again visited the area and took samples of the water and soil from the plaintiff's well and the ground surrounding it and caused a bacteriological examination to be carried out on the samples he had taken.

After the October survey Mr. Connor reached a conclusion similar to that to Doctor McCarthy as to the solid geology of the area.

Rocks

He then concluded that the underlying consolidated rocks are limestone of Carboniferous age. The bedding dips are towards the southeast and there also well marked vertical joint systems, with a north-south trend. The limestones are thick bedded bioclastic limestones.

But he reached a different conclusion about the groundwater system. He pointed out that on the southern side of Knocksouna Hill the surface flow would be in a southward direction towards the river Loobagh and be concluded that the ground water flow direction would be in the same direction as the surface water flow which would mean that it would not be in the direction of the plaintiff's well.

To support this conclusion he prepared a map (map 80/w/30) which showed the watertable contours in the area and which also established, he claimed, that the groundwater flow was towards the Loobagh river and not eastwards towards the plaintiffs well.

The view was expressed in his first report that it would be 'completely impossible' for waste water overflowing from the defendant's yard to pollute the plaintiff's well, and that as pollution occurred after heavy rainfall it was probably local pollution coming from within a few yards of the plaintiff's well, and he pointed out that this type of pollution was not uncommon in farm wells where proper sanitation methods are not enforced in the immediate vicinity of the well.

Samples

He took samples of the plaintiff's water and a sample of the soil from beside the well. Both these samples contained faecal coliforms and Mr. Connor then expressed the view that he could with every confidence state that the source of the pollution of Mr. Berkey's well was the sub-soil surrounding the well and not the defendant's waste water reservoir.

By December, 1980, therefore, Mr. Connor had come to the conclusion that the source of pollution was the soil surrounding the plaintiff's well resulting, he considered from the plaintiff permitting his cattle to be in close proximity to it.

Whilst undoubtedly the soil was polluted, the conclusion which Mr. Connor drew from this fact did not necessarily follow. The pump in the pump-house adjacent to the well had been leaking and the leaking water soaked into the ground at the very point at which the sample was taken by Mr. Connor.

Thus the water from the well polluted the soil (and not vice versa) and evidence of this polluted soil does not establish one way or the other how the well was polluted.

Contours

This witness again visited the area on the 1st February 1982 and the 1st March, 1982. As a result of these visits he prepared a further contour map of the area for the purpose of ascertaining the direction of the groundwater flow.

The elevations of the watertable were measured at twenty – three locations and water-table contours were then constructed. The map (number 82/w/8) shows these contours and also what is claimed as the direction of the groundwater flow which are shown on the map at right angles to the contours.

This exercise confirmed Mr. Connor in the view he had previously held. The flow-lines on the map showed that the groundwater from the defendant's farmyard would flow in the direction of the Loobagh river (i.e. in a southerly direction) and not towards the plaintiff's well (i.e. in an easterly direction) and Mr. Connor expressed the opinion that Doctor

McCarthy's statement as to the source of pollution (which he had read before writing his third report) contravenes the basic concepts of hydrogeology and physics.

Mr. Cullen was the second expert witness call on this aspect of the case on the defendant's behalf. He expressed the view that he would expect the groundwater to flow in the direction shown on Mr. Connor's map and he supported Mr. Connor's conclusions on this aspect of the case.

Contribution

But his main contribution to the debate was on the entirely different point. He challenged Doctor McCarthy's view the area comprised bedded limestone and stated that Knocksouna Hill was a reef knoll. If this was so then the bedding planes described by Doctor McCarthy would not exist and the groundwater could not migrate in the manner suggested.

I think it is important to see exactly how this controversy developed. Doctor McCarthy report (which as I have said, was available to Mr. Connor several months prior to the hearing and on which he recommended in his third report) expressed the opinion that the bedrock geology in the area was well stratified limestones and that there was excellent development of bedding in the area.

When Mr. O'Connor wrote his first report in October, 1980, he stated that the underline consolidated rocks were limestones and that they were thickly bedded. When commenting on Doctor McCarthy report in an affidavit sworn on the 19th November, 1981, Mr. Connor made not suggestion that Knocksouna Hill was a limestone reef or that the area was not one of bedded limestone.

He suggested that there was no sufficient evidence to justify that the bedding occurred as shown by Doctor McCarthy in the figures annexed to his report, but he did not suggest that bedding did not exist or that the hill was, in fact, a limestone reef.

Possibility

The first time that Mr. Connor considered this possibility was when Mr. Cullen was instructed in the case on Wednesday, the 5th of May, the second day of the hearing and at a time when Doctor McCarthy was giving evidence. In a conversation between Mr. Cullen and Mr. Connor that Knocksouna Hill might be a reef knoll. In Friday the 7th May counsel for the defendant very properly requested that Doctor McCarthy be recalled for further cross-examination. This occurred and it was put to him that in fact Knocksouna Hill was reef limestone.

He denied this and gave detailed reasons why this was not so. But it is important to note that on Friday, the 7th May, no detailed examination of the area had been carried out by Mr. Cullen. He had visited it briefly in the evening of Wednesday, the 5th and did not carry out a detailed examination until Saturday, the 8th.

So, the suggestion relating to the solid geology of the area was put to the plaintiff's witness prior to any examination which would establish that the suggestion was a valid one. On Saturday, the 8th of May, Mr. Cullen examined the area and took samples of rock from different parts. On the afternoon of 10th May, Doctor McCarthy was again recalled at the request of the defendant's counsel and again questioned on this point.

But it is most significant that the samples of rock which Mr. Cullen had taken and which he claimed established that the rock was reef limestone were not shown to the witness. There were produced for the first time by Mr. Cullen when he gave evidence on the previous Thursday.

Opinion

On the previous day, Mr. Connor gave his evidence in the course of which he altered the opinion which he had previously held that the area comprised bedded limestone.

He had visited the area again the day before and it would appear that it was as a result of his visit and his conversation with Mr. Cullen that this conclusions on this important aspect of the case were changed.

Mr. Cullen stated that he realised when he was walking up Knocksouna Hill that he was in a reef environment and that the first impression he had was that the hill may be a reef knoll. He explained that the existence of bedding in a reef environment was suspect and he eventually came to the conclusion that the area was not of bedded limestone.

He concluded that the hill was in fact a reef and that the beds were what he termed 'top-of-reef' beds. He stated that he had found reef conditions in the area, particularly to the north of the hill and on either side of the lane way to the defendant's house.

He took samples of the rock which he said confirmed his opinion that the rock was reef limestone. As I have said, Mr. Cullen's conclusions were supported by Mr. Connor, who gave evidence the day previously. He accepted that there were exposed bedded limestones on the hill but in his view these were beds overlaying the reef and that he had seen outcrops of reef limestone in the vicinity of the defendant's farmyard which he had not observed on previous visits.

He stressed that there was no conclusive evidence of the existence of the syncline claimed by Doctor McCarthy to exist in the area and that the existence of the reef made it quite impossible for the bedding to occur in the way suggested by Dr. McCarthy.

I prefer, for reasons which I will develop more fully in a moment, Doctor McCarthy's opinion and conclusions to those of Mr. O'Connor and Mr. Cullen. As to the conclusions based on the water-table gradients, Dr. McCarthy pointed out that it would be correct to draw the flow lines of the groundwater as shown on Mr. Connor's map at right angles to the contour lines if the underlying rock was isotropic.

This, however, is not the case and accordingly it is not correct to assume that ground water follows the flow lines demonstrated in Mr. Connor's maps. Furthermore, Dr. McCarthy pointed out that the flow line shown on map No. 82/w/9 travelling southwards from A and turning westwards below the two hundred foot contour line is not accurate as the hot spring system is a different system to that on Knocksouna Hill.

Error

"And there is a manifest error in map No. 80/W/30 in that the contour line is shown to progress to a non-existent well and in addition the levels shown on the map are not accurate. Most significantly, the defendant's contour theory makes groundwater which the abundant fractures in the bedding plane of the limestone would exercise.

"As to the nature of the bedrock, I accept Dr. McCarthy's view that the bedrock in the area forms an aquifer with a preferred pattern of fractures and that these are the most significant influence on the flow of the groundwater system.

"I accept his conclusion that the area is, in fact, on of the bedded limestone and that he had sufficient evidence from the considerable amount of outcropping in the area to establish the orientation and angles of the beds and the existence of a syncline which plunges in the direction shown on his figures.

"If follows from my acceptance of his evidence as a whole that I also resolve the other, less important, points of controversy in the plaintiff's favour. The idea was canvassed that there might be a fault in the area which would interrupt the flow of the groundwater to the Plaintiff's well but I accept that it is quite proper in the present case to assume that no fault is present.

Water

I accept that polluted water could travel through the alluvial deposit in the vicinity of the plaintiff's well and contaminate it with particles of solid matter and that the rate of flow from both the farmyard and the outwintering unit would not be as suggested by Mr. Cullen from the calculations he made from a sample of alluvial deposits.

I do not think that is it necessary to make three boreholes (at a cost of something in the region of £10,000) in the vicinity of the plaintiff's well in order to reach valid conclusions as to the probable source of its pollution.

"As I have said, there is an abundance of evidence from which an experienced geologist can reach conclusions which on the balance of probabilities established the existence of bedding planes of an angle and orientation and with a fractured pattern described by Dr. McCarthy which would be the dominant influence on the groundwater system in the area.

"I should explain now in a little detail, why I have accepted Dr. McCarthy's opinion and conclusions.

Phenomenon

Firstly, his conclusions gives a reasonable explanation for a phenomenon which would otherwise be inexplicable. From the year 1978 the plaintiff's well has been polluted. There is uncontradicted evidence that since 1980 faecal coliforms have contaminated the well and it can be assumed that this was the cause of the earlier pollution. From whence did they come ?

"From the plaintiff's own cattle ? I am satisfied that this is not so. The plaintiff was a patently honest witness and gave his evidence with care and precision. "I accept that he used the field in the way he described and Mr. Brennan's and Doctor Dodd's evidence supports his testimony which establishes that his cattle did not pollute the well. If they did not, could, then, the pollution be from the river Loobagh ? Again, the evidence shows this could not occur.

"And what about some inherent quality in the soil surrounding the well ? Again, this theory which was but tentatively advanced by Mr. Cullen cannot be supported by the facts of the case.

Over-Flow

"Dr. McCarthy conclusions that pollutants from the over-flow at the slurry tank and from the area of the outwintering unit enter a groundwater system which flows to the plaintiff's well is the only rational explanation for what has happened to the plaintiff's well.

"Secondly, his conclusions find support from the evidence. In June, 1980, both the plaintiff and Mr. Brennan noticed a distinctive smell of silage in the water from the well.

"The defendant had cut silage on the 22nd May and placed it in his out-building. The channels around the slurry tank were at that time blocked and quagmire conditions at the rear of the tank were seen in the month of June both by the plaintiff and Mr. Brennan.

"Neither the plaintiff nor any of his neighbours had made silage at that time and the only way that silage could contaminate the plaintiff's well was through the groundwater system as described by Dr. McCarthy.

Seepage

"Furthermore, his evidence that seepage from the lagoon at the outwintering unit would enter the same groundwater system gets support from the fact established by the evidenced by the evidence. In February, 1982, the plaintiff's well was still contaminated even though no overflow was then occurring at the slurry pit.

"Massive accumulations of effluent existed, however, at the outwintering unit which obviously seeped into the groundwater system. There had been no cattle on the plaintiff's land for some months prior to this date and yet the well was heavily polluted.

"These facts suggested that the groundwater system flows as Dr. McCarthy has described.

"Thirdly, I was impressed not only Doctor McCarthy's qualifications and considerable experience but also by the detatched manner in which he gave his evidence. On the other hand, it seemed to me that the Defendant's witnesses on this aspect of the case strayed from time to time from the role of objective scientist into that of enthusiastic advocate.

Validity

Furthermore, in the circumstances of this case, I found unconvincing an intellectual position which denied the validity of an explanation for the pollution of the Plaintiff's well but declined to provide any plausible alternative. I must also state that I was influence (not, I hasten to add, decisively influenced) by the fact that no explanation was forthcoming as to why Mr. Cullen did not produce for comment by Dr. McCarthy when he was giving evidence on the 10th of May, the rock samples which Mr. Cullen had obtained on the 8th May and which he said established the existence of reef limestone.

"The absence of explanation suggests that the failure to give Dr. McCarthy such an opportunity was not due to inadvertence"

In his conclusion, the judge stated: "I am satisfied that the contamination of the Plaintiff's well is caused by pollutants coming from the overflow at the Defendant's slurry pit and/or from the outwintering unit on the defendant's land.

Submission

"I do not think that it is necessary for me to consider the submission made on the Plaintiff's behalf that the rule in Ryland V. Fletcher applied in this case as the Defendant's land then the Defendant is liable in nuisance to the Plaintiff.

The parties have agreed that the plaintiff has suffered a special damage in the sum of £4,000 as a result of the pollution in his well and I award this sum to him.

"In addition he is entitled to a sum of which I measure at £500 for general damages arising from the inconvenience he has suffered. This sum of £4,500 should be payable forthwith.

By agreement with Council I have left over the question of whether or not an injunction should be granted and the form it should take, if it is to be granted. I will hear Councils submission on this point.

Nuisance

"A motion for committal arising from the breach of the interlocutory order was brought against the Defendant and by consent was heard at the same time as this action.

"It was, in my judgement, properly brought as the nuisance was not abated and no effective steps to remedy the overflow conditions at the slurry pit were taken until after it was issued. But as a final order will now be made it is unnecessary to make any order on the motion other than one in relation to costs."

3. A Concluding Note by The Author

Judge Costello concluded that the area was underlain by bedded limestone. It is interesting to record that the recently published geological map of the area shows Knocksouna Hill as being composed of unbedded reef limestone !

8. The Need for a National Well Standard and Suggested Content

David M. Ball, Consultant Hydrogeologist

THE NEED FOR A NATIONAL WELL STANDARD AND SUGGESTED CONTENT

David M. Ball
Consultant Hydrogeologist
Emmet Bridge House, 38 Upper Clanbrassil St., Dublin 8

Abstract

The drilling industry is essentially un-regulated. The drilling profession and other groundwater professionals concerned with the poor state of the country's water supplies know that there is a need for a standard that regulates the drilling or construction of all boreholes and wells. A series of key issues that should be covered in the standard is given. The standard is needed to protect the health and promote the development of the country. The full implementation of a Standard will reduce the need for 'end of pipe' clean up solutions. In the long run, the improvement of the sources of water will be more sustainable than treatment systems that are costly to maintain and manage.

1 INTRODUCTION

Ireland has no standard to guide and govern the location, design, construction, testing, certification and destruction of water wells and boreholes.

The drilling industry is also unregulated. As someone once pointed out; you need to pass a test in order to be permitted to drive a bus, but you don't need a licence to be able to drill and provide a water supply.

People who want a new water supply are able, without reference to any regulatory authority, to commission their own drilling contractor and sink their own borehole.

I have mentioned in this forum on several occasions the need for a National Water Well Standard in Ireland. I spoke on this subject at this Seminar in 1995 and again in 1996. I have had no response from either the regulatory authorities or other hydrogeologists about for example setting up a working group or being commissioned to write such a standard. The best response that I have had is from conscientious drillers, who feel that they are exposed working in an un-regulated environment, and they are not able to provide the both institutional and domestic clients with the best service.

Hydrogeologists and drillers are aware that there are large number of poorly sited and constructed boreholes in the country that have failed to meet expectations either in terms of yield or in terms of quality.

The absence of a National Standard is not just a issue of inertia, tardiness or lack of information. It is a bigger and more complex issue, that involves myths, old perceptions and romantic notions that are important for ordinary people. I have put forward technical issues and specifications in the papers that I presented in other years. I will return to the technical aspects towards the end of this paper, but to begin I think it is necessary to shine a light on some of the perceptions that float around the periphery of our profession, yet have a significant bearing on the standard of drilling.

2. BACKGROUND PERCEPTIONS

Drillers recognise that they are essentially experts at making holes in the ground. Unfortunately their domestic and, still to a certain degree, institutional clients, are usually not clearly informed, and they think that drillers are experts at providing water supplies. They do not recognise that drillers do not have the training or the equipment or the time to do the work necessary to provide a sustainable high-quality groundwater.

Another problem perception for hydrogeologists and in particular the drilling industry is the prevalence of a **'no foal no fee'** attitude prevalent amongst private domestic clients. This also rubs off on other clients. Clients are still leaving the responsibility for finding water to the driller. If the driller it does not find water then he does not get paid. This attitude, is common, and has become so embedded in society's thinking, that to suggest that a driller should be paid for a dry hole, would raise eyebrows amongst many.
In my opinion a driller should be asked to use all his or her skill, experience and equipment to construct a hole in the ground to an agreed appropriate design.
It is both naive and unreasonable to expect a driller to take responsibility for insuring that Nature will provide the quantity and quality of water that a client requires. There is this sense amongst many drillers; that if the client can't see that the driller has 'struck a great spring of water" then in some ways the driller has failed. Drillers and perhaps even hydrogeologists, when faced with this ridiculous expectation, have been known to make it appear that the 'great spring' has been found.
Water divining may have something to do with this attitude. We should perhaps look at the implications of the word 'diviner' because it is a powerful word. One meaning of the word divine is "of God". Even though no diviner would pretend to be omniscient, the word itself suggests that a diviner has supernatural powers. People therefore often believe this and suspend their sense of disbelief and other critical faculties when faced with a 'divined water supply'. They ignore the sound of cascading water ten feet down the hole and the presence of a septic tank a few yards away.
A realistic role for the drilling profession needs to be defined. A drilling standard could achieve this easily and I believe the profession would be able to improve and break away from the unrealistic expectations from the past.
Drilling rates, as I have illustrated before, have not changed for forty years. The old idea that drilling is £4 -£5 per foot is still held. It must appear to be the most inflation proof cost in the national economy. The reason why this rate has held steady is that drilling machines have become faster and more efficient. In the old percussion rig days it could take a week to drill to say 150 feet. Now with a down-the-hole-hammer rig that depth can be achieved in hard limestone by lunchtime.
However, hidden behind this apparent inflation proof rate and the gains in efficiency, and in conjunction with the "no foal – no fee" attitude of clients, there is a drilling agenda brought about by pure commercial survival. This agenda leads to a method of working that has significant and far reaching implications for the standards of drilling in the country, the protection of our groundwater resources and the reputation of Ireland's water supplies in the eyes of the EU.
The drilling agenda based on commercial reality is 'make deep holes quickly'. Drillers are not paid to take time and care to construct sustainable, well protected water supply wells. Drillers need to bring in about £1,000 a day in order to stand still. They have to drive long distances, spend time setting up, pay for diesel, wages, insurance, and materials and make enough money to maintain equipment properly and buy a replacement rig after a few years. As a result there are a large number, perhaps a majority, of unnecessarily deep boreholes in the country. Many of these holes strike little water in the bedrock. They are often , in effect, long expensive, dry sumps. The need to find water in order to get payment, is added to this state of affairs. The bleak financially unrewarding result of a long dry bedrock hole, then encourages the driller to partially pull back the 20 – 40 feet of casing sealing off the shallow overburden or the fractured and weathered upper layer of the bedrock, in order to see if a little water will weep in under the casing and provide a sufficient yield. There is no discussion (as hopefully a cheque is signed) of the probability that this shallow groundwater is the most vulnerable to pollution. It could be said that for the drilling profession to survive commercially they are often encouraged to break the one (though often inadequate) seal that might protect the water supply from being polluted.
This agenda or necessity is something that we all know, but we don't really address. Part of the reason for this is that hydrogeologists with experience are seldom involved in drilling the majority of boreholes in the country. It is obvious that we need both an enforceable standard and clear blunt information in order to break this pattern. Most of the holes that are currently drilled in Ireland and grant aided by the DoE are drilled within the constraints of this commercial agenda.

3. THE SCOPE OF A NATIONAL DRILLING STANDARD

It is not easy to decide on the scope of a National Drilling Standard.

The scope and framework of a standard depends on the agency that promotes the drafting of the standard, administers the registration of certification of the drilling and groundwater professions and then enforces the standard.

I hope that at the end of this paper there can be an exchange of ideas on the subject of which is the most appropriate agency to take up the challenge.

For example, Ireland has an Irish bottled Water Standard (IS 432:(92). This was prepared by hydrogeologists for the National Standards Authority of Ireland. It is a Standard that was drawn up to essentially inform the Bottled Water Industry of the standards that should be met in order to sustain a high quality source, bottling facility and product. It contained obligatory phrases, but in tenor was essentially a document designed to inform. A similar standard for drilling that described 'good practice', but without a mandatory or legal aspect, could perhaps be published in one to two years depending on the energy of committee. . The National Standards Authority of Ireland could provide a sufficiently strong framework for a new drilling standard. The standard would have some degree of credibility. This might be a simple route.

The EPA and or the DoE have the power and the remit to prepare a standard, and may already be working on this issue. The difficulty I would foresee in the short term is the acquisition of sufficient resources in terms of experienced staff and budget to be able, in the near future, to administer and enforce a standard for every domestic borehole in the country. I can also foresee difficulties because groundwater is a food, it is a fundamental part of the environment, it is a health issue and it has a large bearing on planning and rural development. All of these may have to be taken into consideration. There are regulations and agencies in all these areas, and hence there may be large committees and a long gestation period.

I believe that a Standard can be brought into place if, initially, it were kept simple, informative and dealt with the core issues. Part of the work has also been done already by the Geological Survey and the I.G.I.

I suggest that the **core issues** are as follows:-

1. A definition of the subsurface structures covered by the standard
2. Borehole location and protection of wells and boreholes
3. Effective sealing of the borehole annulus
4. Proper Casing and Screen
5. Pump chamber Casing
6. Certification of Drillers
7. Certification of other groundwater professionals
8. Proper testing of yields and chemistry/microbiology
9. Open screen sections across multi-layered aquifers below contaminated land
10. Destruction of abandoned or unused boreholes and wells

These issues can be implemented by a process of licensing using application forms and certification by a regulatory authority. It could be a process similar to the planning process. A process that requires the applicant to come forward with certain details and engage a certain level of expertise. The legally enforceable or obligatory parts of the standard should be very simple and clear, but must be supported by a series of very clear hard hitting information documents that dispel some of limiting perceptions from the past. There are many examples from other parts of the world.

4. COMMENTS ON THE CORE ISSUES AND EXAMPLES FROM ELSEWHERE

Structures included in the Standard

A definition of the subsurface structures that will be included in the standard is required. Water supply boreholes are obviously included, but I would suggest that the standard and the licensing procedure should also include exploration boreholes, monitoring boreholes, observation boreholes, site investigation boreholes and trial pits, injection boreholes, geothermal energy boreholes, dug wells, well points, dewatering wells or sumps and retention or destruction of abandoned and unused wells and boreholes.

Borehole location and protection

The Geological Survey and the EPA have gone a long way towards covering the issue of borehole site and location. The principles of the source protection scheme could be tailored to the domestic borehole scale. However at this scale an emphasis must be placed upon proximity and interference with existing boreholes. I recently encountered six 'up market' detached houses in adjacent quarter acre plots in Meath. Each site had been sold and developed separately about 10 –15 years ago. Each house had its own borehole straining to pull water from the Calp limestone, and its own septic tank. None of the owners had any awareness that the adjacent houses were both taking water from and adding polluting water to, the limited groundwater system upon which they depended. All of them had quality and capacity problems. None of them were talking to the others. One family had not felt it was safe to have a shower or bath for eight months and were collecting rainwater for drinking but was not prepared to admit this to the neighbours.

A simple form requiring the applicant to locate and provide information on all boreholes within say 500 metres and then submitted to the regulatory authority would have helped.

Effective sealing the borehole annulus

This aspect of drilling is in my opinion one of the most important parts of the standard. A full implementation of a requirement to properly seal the annulus will bring about a radical improvement and change in drilling practice in the country. It will move the basis from the objective of making a hole and finding water to the basis of constructing a sustainable water supply. It will mean that drillers will have to be paid for something other than making a hole. The drilling contracts will include items that are charged on the basis of time and materials and not just footage and diameter.

The wording of the specification for sealing the annulus need not be complicated.

For example the Santa Clara Valley Water District Summary of Standards for Water Well construction states quite simply the following:-

- Permit and license requirements

Permits are required for all wells. Please call (telephone number) for permit application forms. There are no fees for permits. Drilling contractors must have a current California C-57 contractor's license.

- Minimum annular sealed depth and radial thickness

A minimum 50 foot seal is required in bedrock wells. District Well Standards are more stringent than State water Well Standards. Special sealing depth requirements will be determined by the District on a case by case basis. Seal depth requirements will be specified either at the time the permit is issued or following completion of a test hole. A minimum 2 inch radial thickness of annulus seal is required by State Well Standards.

- Acceptable sealing materials and seal placement method

Acceptable sealing materials are 27 sack neat cement, (4x 94 lb. bags per 55 gal. Drum), 10 sacks cement sand grout, or hydrated high solids 20% bentonite slurry. No bentonite chips, pellets, or gel are allowed except for maximum of 3 foot thick transition seal directly above filter pack.

- Placement of sealing materials

Free fall of the sealing material is not allowed if greater than 30 ft. or, if more than 3 feats of standing water exists in the annulus. A tremie pipe must be used to place the sealing material if the seal is over 30 ft. deep or water is present in the annulus. Tremie pipes must be placed such that no sealing material will free fall more than 30 ft. or through more than 3 ft. of standing water.

- Environmental health department approval

Health Department approval is required for wells of that will provide drinking water. Any of what to supply wells with sanitary seals less than 50 ft. deep must be pre-approved by the County Health Department. All domestic and municipal water supply wells must be located at least 100 ft. from any septic tank or leachfield

I disagree with the 30 foot free fall being permissible, but this is a detail that can be decided in a committee or working group. There are many more versions of standards covering this aspect of completing a proper borehole. Another example from a County Ordinance covering well standards is

B. All annular well seals shall extend at least five feet into the first low permeability stratum encountered, or to fifty feet, whichever is the lesser depth.

1. No well seal shall be less than twenty feet deep except as provided in Bulletin 74-90.
2. Where the low permeability stratum is less than five feet thick, the annular seal shall extend through its entire thickness.
3. Steel well casing shall be no less than ten gauge in thickness. (Ord. 982 § 6)

I am certain that a working group can draw up a simple clear specification for grout sealing the annulus and for minimum depths of casing for an Irish national Standard.

Proper Casing and Screen

The cost of casing and even rudimentary screen is often included in the drilling price. The cost of the time and care necessary to place or drive the casing is usually not included in the drillers charges. As a result cheap and inadequate materials are used, such as thin walled steel, thin walled PVC ducting or brown PVC sewer pipe is used. Steel is also used and left exposed when the water is known to be corrosive. These malpractice's arise because from the present payment arrangements for drilling.

There are many existing sets of guidelines and standards for selecting and emplacing casing and well screen. The emphasis in these documents is on wall thickness, effective jointing (i.e. no holes in the welds or couplings) strength and resistance to hydrostatic pressures and pumping pressures to prevent deformation particularly in PVC pump chamber casing.

Pump chamber Casing

I described the concept of a pump chamber casing at length in the last paper during the Portlaoise Seminar in April 1995. I propose that a pump chamber casing should be obligatory in all water supply production boreholes where a submersible lineshaft or electric pump is installed. The objective of the pump chamber casing is to protect the pump and enable it to be with drawn freely. This will avoid a common occurrence of boreholes going out of commission because a broken pump is trapped in the hole by falling debris from the unsupported borehole sides. It is also to discourage overpumping and an abuse of boreholes that usually leads to a decline in yield and efficiency caused by the build up of biofilms.

Certification of Drillers

The certification, registration, regulation or licensing of drillers is normal in other countries. Drillers elsewhere take a pride in the fact that they have been licensed. In Ireland anyone can claim to be a driller. I know that reputable drillers, local authorities and professionals in the water industry would like to see the drilling industry being regulated. There are many examples of poorly informed clients employing untrained, inadequately experienced and poorly equipped drillers who leave problems for the clients and responsible members of the water industry in their wake.

The regulation of the drilling industry can be achieved in broadly either two ways. The first could be a requirement for the drilling company to meet and adhere to certain quality standards and procedures, which would involve accountability, record keeping, traceability training and health and safety. For example a relatively straight forward but onerous quality system is currently applied to a wide range of companies and businesses in Ireland. The procedures covered by this standard are:- Management review, Contracts review, Document control, control of purchased products and services, Identification and Traceability, Field Services, Inspection, Testing and calibration, Internal and external services, Corrective action, Storage, Quality records, auditing, Training, and Health and Safety. A modification, adaptation or extension of an existing quality system could provide a fast track method of improving and regulating the drilling industry.

The second method of licensing or certifying the industry would in the long run be most effective but it would be difficult to implement. This would be a process of tests, exams, inspections, and controls on a company, its staff and equipment that would require a well defined training programmes and equipment maintenance programmes. I am perhaps being pessimistic but I see that given the present lack of any form of national driller training programme and no drilling regulations, it will be difficult to set up. I propose that an agency such as the EPA should set up a working group that involves all the drillers who wish to

participate, and experienced representatives from the IGI, IEI and government departments to decide the most effective way of bringing about the regulation of the drilling industry.
The health and development of the nation is a matter of national importance. The provision of better domestic water supplies by improving and controlling the main industry that provides these supplies should also be a matter of national importance.

Certification of other groundwater professionals
I could make many proposals in this area but I know that this is covered by the IGI and the IEI. I would just add that university education to MSc level does not provide either training or experience in drilling supervision. Most graduates have never seen a drilling rig or constructed a well or borehole. I would also add that it is quite possible to gain 5 or 7 years post graduate experience in hydrogeology without drilling a water supply well or borehole. Some members of the profession could spend their careers concerned solely with mathematical modelling, contaminated land or landfill design.

Proper testing of yields and chemistry/microbiology
There are already well recognised standard procedures and guidelines for the design, set up, conduct, completion and reporting of pumping tests. I suggest that a standards needs to be drawn up and that this will be a relatively straightforward process.
Water chemistry and microbiology sampling, analysis and reporting is subject to very wide variations in practice. Even though there are clear EU and EPA standards and guidelines, we still have a state of affairs where neither clients or water supply owners know what should be analysed and individual laboratories feel free to decide their own suite and method of analysis. We need to draw up a standard suite of analyses for basic, but comprehensive groundwater analysis. The suite of parameters should cover the basic requirements for water quality but I strongly suggest should include key chemistry parameters so that the nation can build up a better understanding of the groundwater and aquifer characteristics and flow regime. I think that it is important that we standardise reporting units and analytical methods for parameters such as phosphate, nitrate, nitrite, ammonia, sulphate and electrical conductivity and total dissolved solids.

Open screen sections across multi-layered aquifers below contaminated land
Site investigation and contaminated land monitoring boreholes must be brought into the standard. It is commonplace for site investigation boreholes, which were initially aimed at providing geotechnical information for foundations to be used for obtaining groundwater information. These holes are often lined or screened as an afterthought. Frequently a well screen is emplaced through two or more fill, alluvial or glacial aquifer units. The upper units may be contaminated or heavily polluted. The lower units maybe uncontaminated. The lower units may be confined aquifers that are subject to tidal pressure changes and therefore at some times of the day water may rise from the lower units and invade the upper unit. Conversely water may drain from the upper unit and result in contamination of the lower units.
The standard should define permissible methods of constructing, completing and closure of site investigation boreholes. The standard would provide an essential measure to protect the groundwater resources below cities, towns and industrial areas.

Destruction of abandoned or unused boreholes and wells
Abandoned boreholes and wells are a threat to health and the quality of our groundwater resources. In many other countries it is a serious offence to leave or abandon a borehole. Boreholes (including exploration holes and site investigation holes) and wells provide a zone of high permeability or a conduit for polluting matter from the surface or shallow aquifer zone to enter the deeper groundwater system.
There are thousands of abandoned boreholes and wells in the country owned by private individuals, farmers, local authorities, group schemes and industries, that have gone into a state of disuse. Many of these holes were deemed at the outset to be failures because the water supply turned out to be insufficient or polluted. Lack of understanding has lead to bizarre examples of unwitting pollution of groundwater via

boreholes. For example a dungstead placed on top of a borehole; dead cattle (TB reactors) dumped down old stone lined dug wells. Engine oil, creosote, and grease solvents being either dumped down unused holes or allowed to seep into 'soak aways' next to wells and boreholes.

As drilling standards and information bulletins increase public awareness of the previous poor standard of boreholes, there is going to be an increase in the number of boreholes that become abandoned. Each one could provide a conduit for septic tank effluent, silage effluent, dung, slurry or dirty farmyard water to seep down into the aquifer and provide a continual source of pollution for any subsequent water supply borehole or well nearby.

The serious nature of this risk is clearly spelt out under the guide to the California water well laws examples from which are as follows:-

> Every person owning land in fee simple or in possession thereof under a lease or contract of sale who knowingly permits the existence on the premises of any permanently in active well, or monitoring well that constitutes a known or probable preferential pathway for the movement of pollutants, contaminant, or poor quality water, from above ground to below ground, or vertical movement of pollutants, contaminants, or poor quality water below ground, and that movement poses a threat to the quality of the waters of the state, shall be guilty of a misdemeanour.
>
> A 'permanently in-active well' is a well that has not been used for a period of 1 year, unless the person owning the land demonstrate an intent for future use for the supply of ground water or monitoring.
>
> At a minimum, permanently inactive wells shall be destroyed in accordance with standards developed by the Department of Water Resources pursuant to section 13800 of the Water Code.

By contrast the DoE form for the Water Supply Improvement Grant Scheme does not request information on the status or failure of the previous water supply, nor does it request information on the steps that have been taken to destroy, or decommission the previous source. Whereas in Canada and the United States it is necessary by law to seal, plug or destroy unused boreholes, it is also necessary to obtain a license to commence the work. Part of the licensing procedure requirements are reports from relevant bodies or consultants to show that it is safe to plug the hole. The regulatory authorities want to make sure that the hole and aquifer around is clean before it is plugged. It is normal for the hole and backfill material adjacent to the aquifer to be sterilised by chlorine before the final filling with cement grout.

5. CONCLUSION

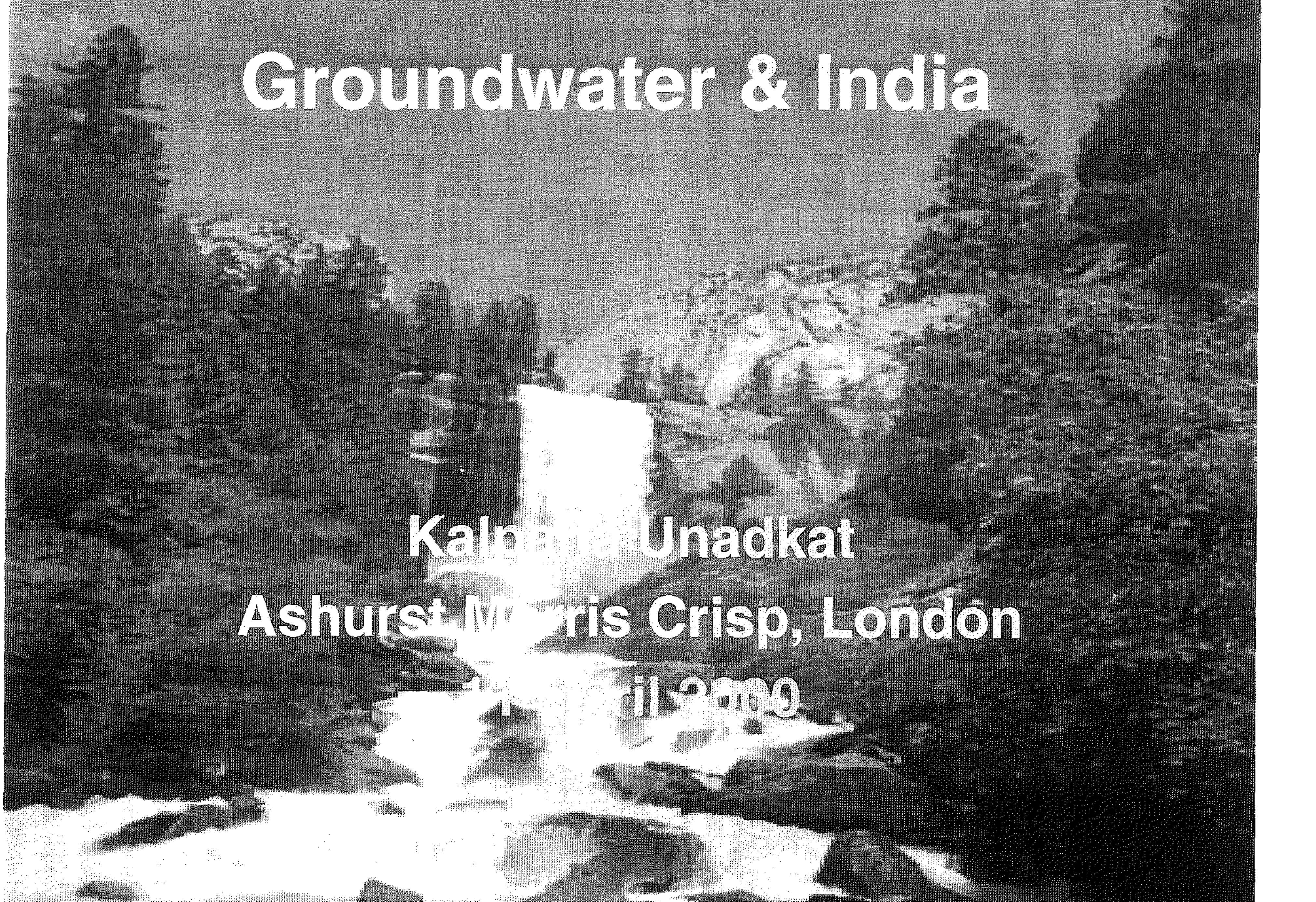
A national standard to improve and regulate the water well and drilling industry is required. The danger in drawing attention to this, is that the task will appear to be too daunting, and nothing, yet again, will be done. I believe that to move ahead, we should not dwell upon the past and the enormity of the apparent gap we need to fill to catch up with thinking and legislation elsewhere. I believe that we should recognise the present limiting perceptions, but then focus on how easy it will be to change things. There are many examples of standards from other countries. We can easily select and adapt the best from elsewhere. I believe that we can make a considerable advance in this area in a year if one or more regulatory agencies accept the need for the standard, and commits to its creation and implementation.

Minister for the Environment two weeks ago again referred to the availability of 85% grants for the capital costs to enable "quality deficient" group schemes in up grading their treatment systems, and went on to warn that "sub standard water supplies could not be tolerated in this day and age". He further added that "to those that may be less receptive, all I will say is: shape up or ship out. By 'ship out', I mean hand over responsibility to the local authority who will then have to do the job for you."

What this and other similar statements appear to be saying is that we must accept that our water resources, and the water wells that draw upon them, are inadequate, and therefore we must bolt on an 'end of pipe solution' to improve standards. I am not against appropriate treatment of water supplies, but the purpose of this paper is to draw attention to a much more sustainable solution in the long run which is to get the source right at the beginning. If the source is right then there is no need for the 'end of pipe clean up'.

9. Groundwater & India

Kalpana Unadkat, Ashurst, Morris, Crisp, London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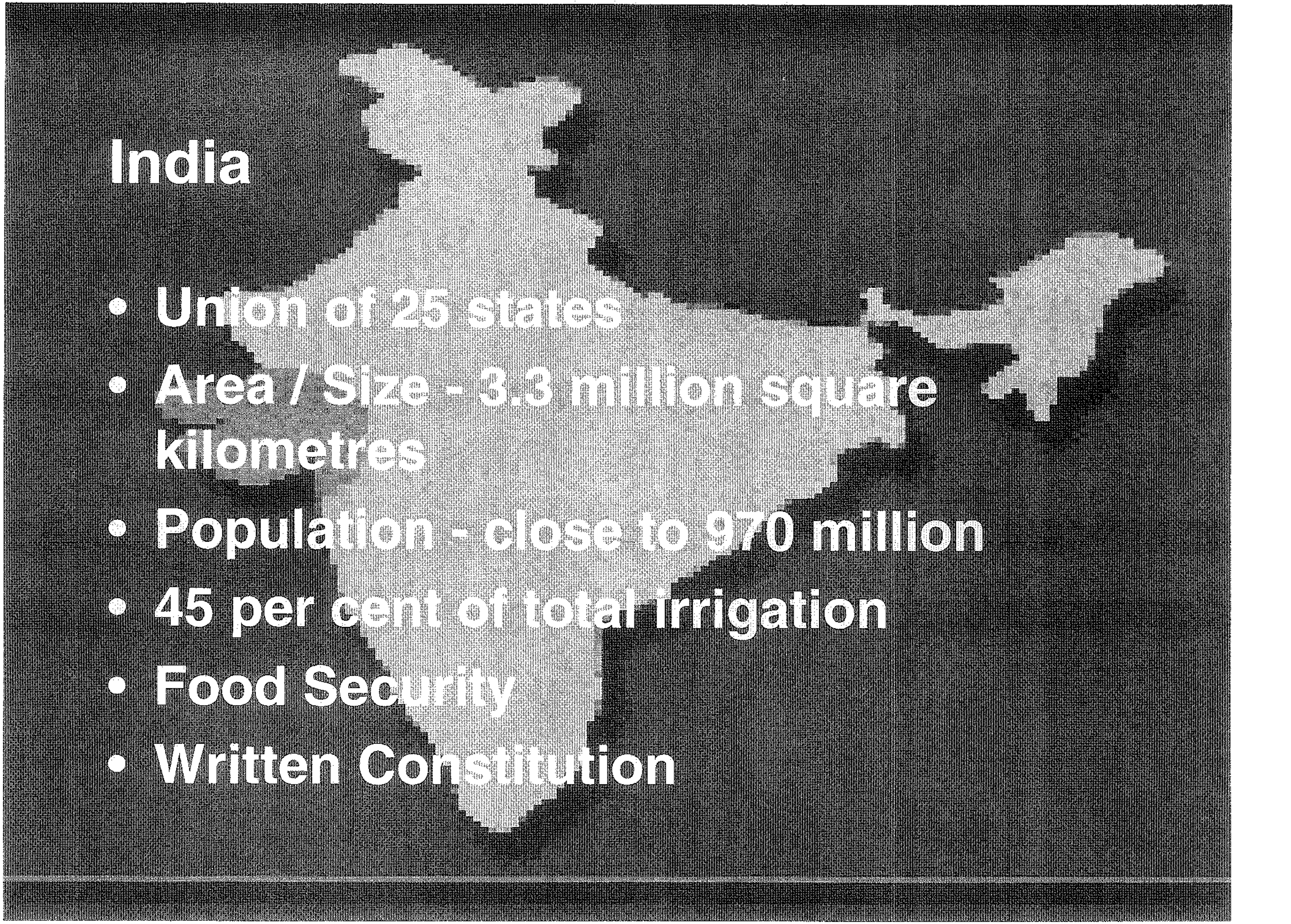

India
• Union of 25 states
• Area / Size - 3.3 million square kilometres
• Population - close to 970 million
• 45 per cent of total irrigation
• Food Security
• Written Constitution

Climate

- Rainfall
  - Between June and September
- Temperature
  - Maximum - 48 degree centigrade
  - Minimum - below 0 degree centigrade
- Evaporation
  - 150 to 250 cm

Groundwater Development

- Shallow Groundwater Structure
  - Dug Wells
  - Dug-cum-Borewells
  - Shallow Tubewells
  - Filter Points
  - Maximum 50 m depth
- Deeper Structure - 50 to 300 m
  - Heavy Duty Tubewells and Borewells

Hydrogeological Situation

- Rock Formation
  - Porous formations
  - Acquifers interconnected - moderate to high yield potentials
  - Consolidated and fissured formations
- Sindhu Ganga-Brahmaputra - largest groundwater reservoir in the world

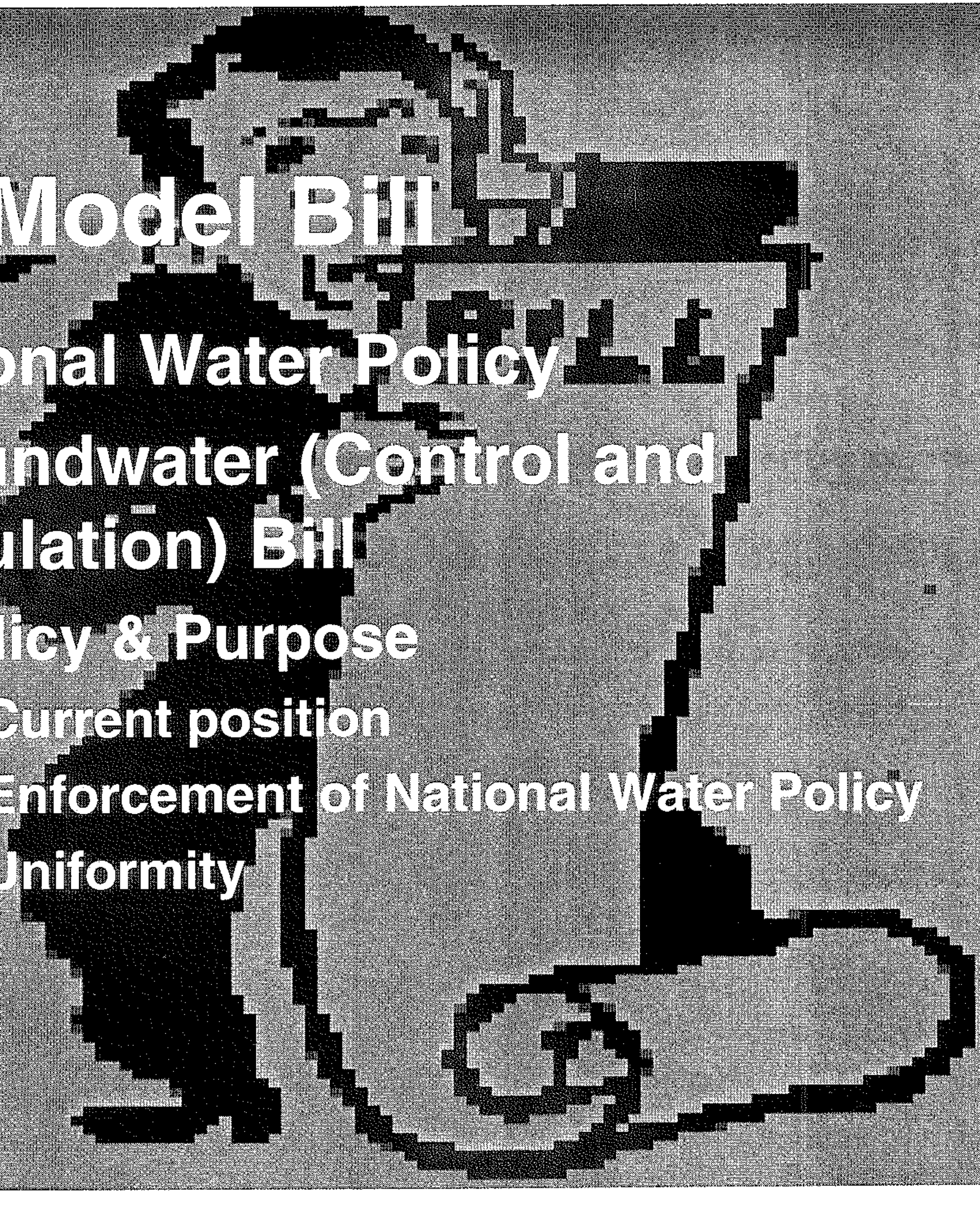
Law

- The law of easements
- Water - States' powers
- State Legislations
  - The Mysore Irrigation Act, 1965
  - The Bombay Irrigation Act, 1879

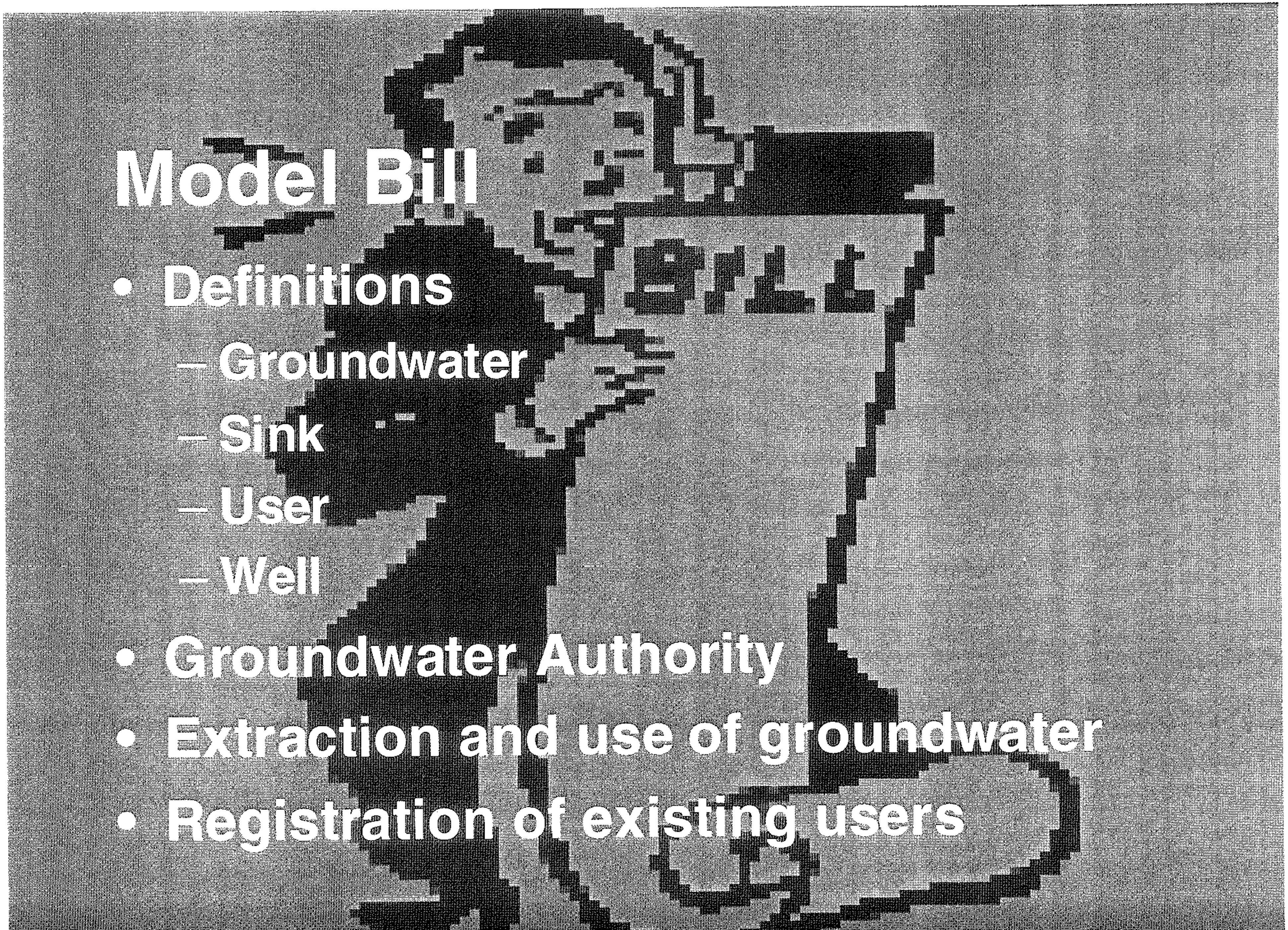
Authorities

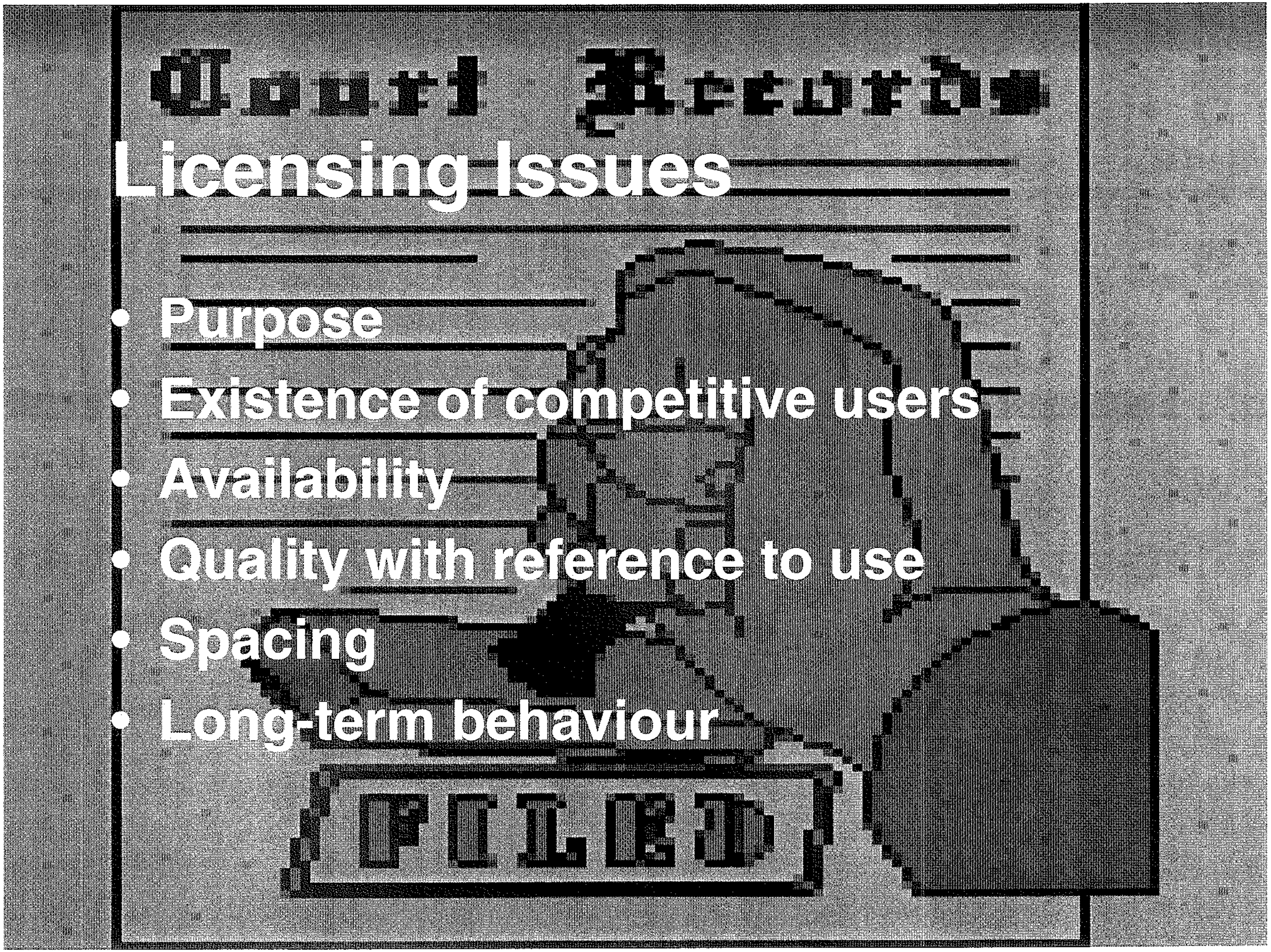
- Ministry of Water Resources
- Central Groundwater Board
- State Groundwater Board
- Local Authorities
- Central Pollution Control Board
- State Pollution Control Board

The Model Bill



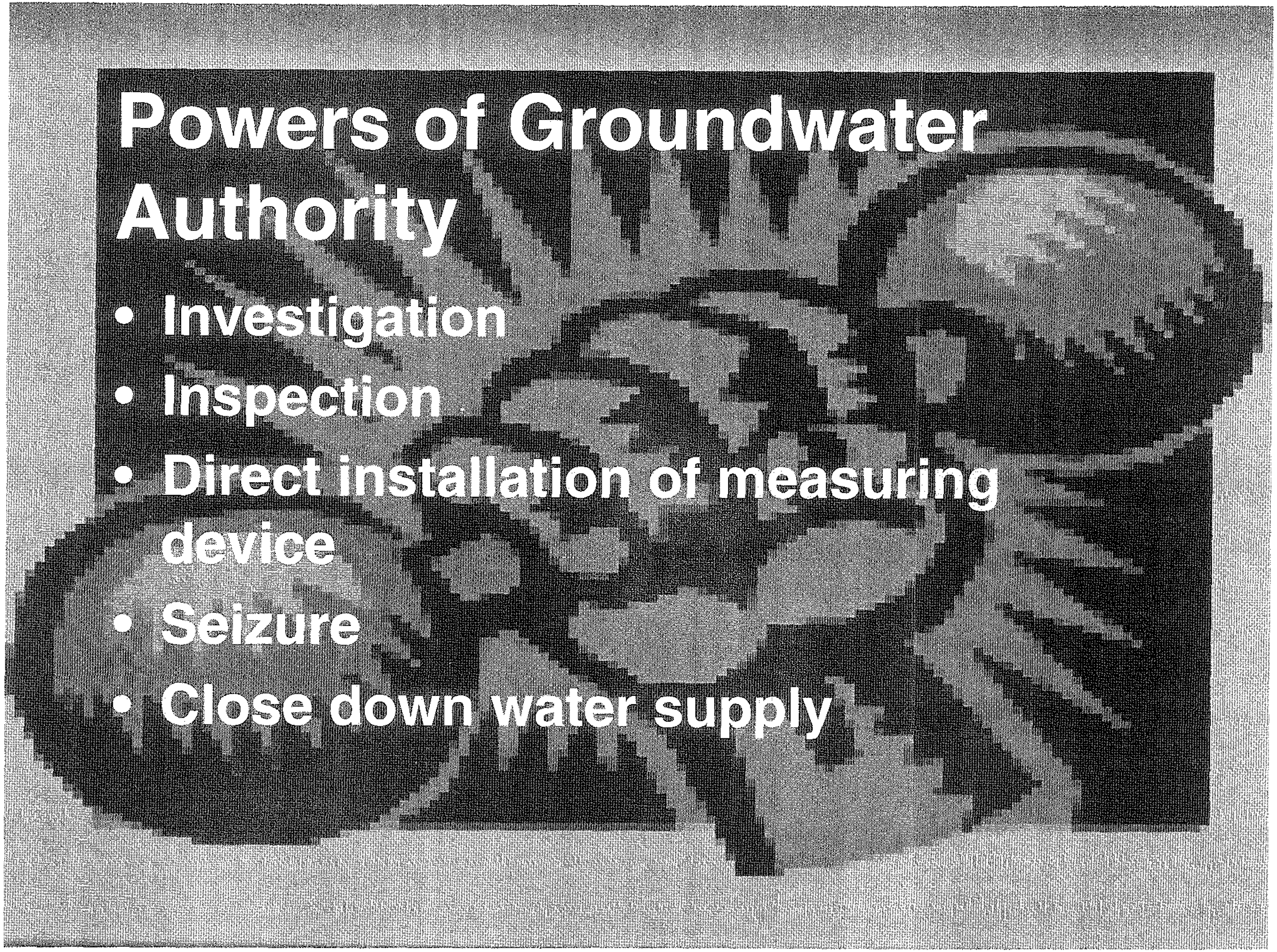
- National Water Policy
- Groundwater (Control and Regulation) Bill
  - Policy & Purpose
    - Current position
    - Enforcement of National Water Policy
    - Uniformity


Model Bill
• Definitions
– Groundwater
– Sink
– User
– Well
• Groundwater Authority
• Extraction and use of groundwater
• Registration of existing users
BILL


Court Records
Licensing Issues
• Purpose
• Existence of competitive users
• Availability
• Quality with reference to use
• Spacing
• Long-term behaviour
FILED

Powers of Groundwater Authority

- Regulatory Power
  - Grant of Licence
  - Alter, Amend or Vary Licence terms
  - Cancellation
    - Non-compliance with terms
    - Limit use or extraction

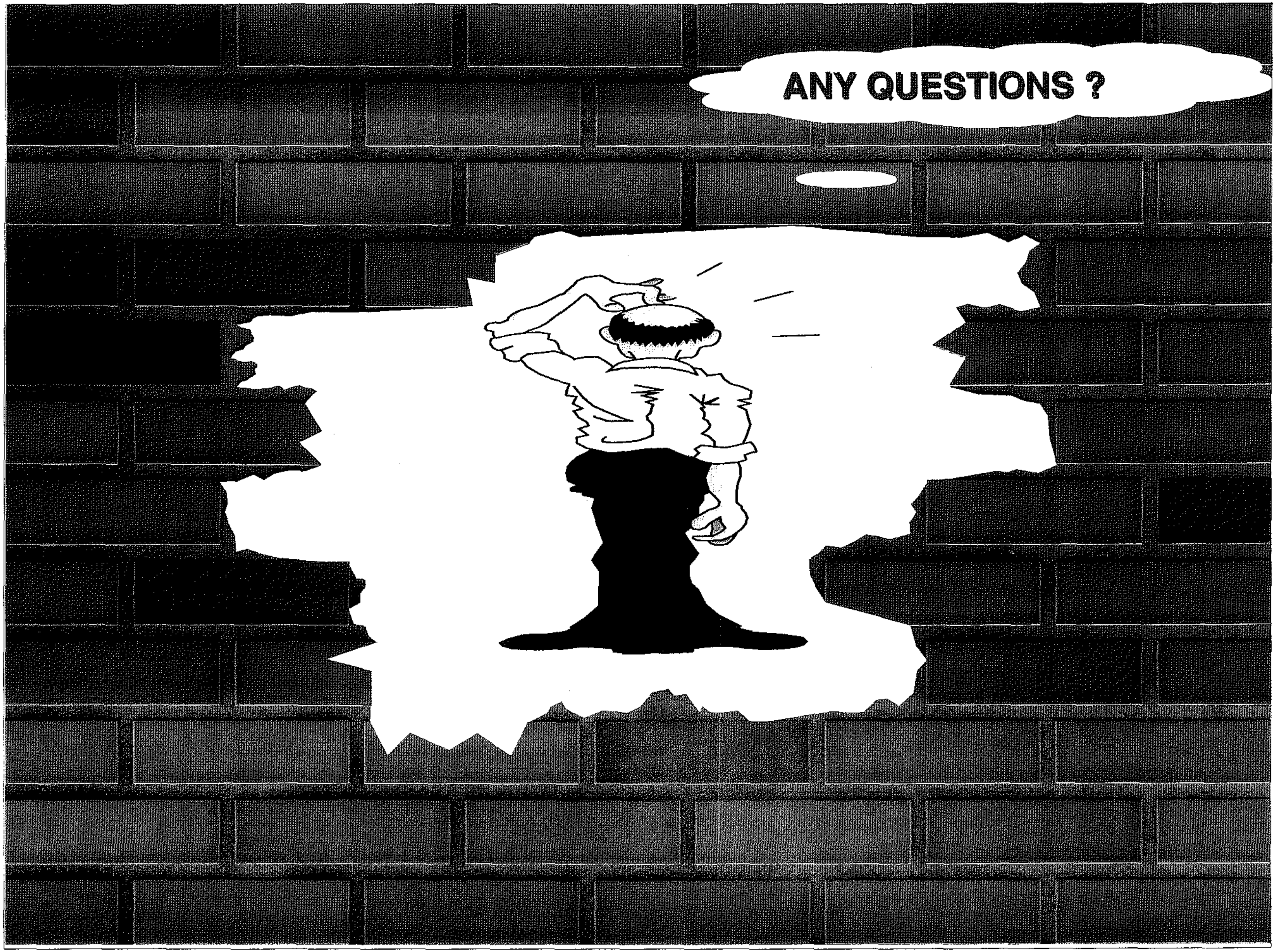

Powers of Groundwater Authority
• Investigation
• Inspection
• Direct installation of measuring device
• Seizure
• Close down water supply

Groundwater and Environmental laws

- The Environment (Protection) Act, 1986
- The Water (Prevention and Control of Pollution) Act, 1974 and Rules
  - Prohibits discharge
  - Consent of the State Board for industrial activity
  - Central and State Pollution Control Boards

Conclusion

- Management of Groundwater Resources
  - National Policy
  - Structured Responsibility
  - Uniformity
- Model Bill
- Opportunities?


ANY QUESTIONS ?


Groundwater & India
THANK YOU!
Kalpana Unadkat

10. Groundwater Quality Standards in the Netherlands: Derivation & Application

J. P.A. Lijzen & F. A. Swartjes, National Institute for Public Health & Environment

GROUNDWATER QUALITY STANDARDS IN THE NETHERLANDS: DERIVATION AND APPLICATION

Johannes P.A. Lijzen and Frank A. Swartjes
National Institute of Public Health and the Environment,
Soil and Groundwater Research Laboratory,
P.O. box 1, 3720 BA Bilthoven, The Netherlands

ABSTRACT

To assess groundwater quality two generic (i.e. multifunctional) risk-based standards, Target and Intervention Value, have been developed, in the framework of the Dutch Soil Protection Act. These standards allow groundwater to be classified as clean, slightly polluted or seriously polluted. The Target Value is based on potential risks to ecosystems, while the Intervention Value is based on potential risks to humans and ecosystems. In the case of serious groundwater contamination the site has, in principle, to be remediated, making it necessary to determine the remediation urgency on the basis of actual (i.e. site-specific) risks to humans and ecosystems and of actual risks due to contaminant migration.

1. INTRODUCTION

This paper describes the procedure for deriving the risk-based quality standards for groundwater and presents the procedures to determine the remediation urgency for contaminated sites. A differentiation is made between potential and actual risk assessment. Potential risk is the risk that would occur under "standardised" conditions and is independent of site-specific characteristics like land-use. Actual risk, on the contrary, is based on site-specific risks, e.g. site-specific human exposure and risks due to contaminant migration. Actual risk is a function of land-use, human behaviour, soil characteristics, et cetera.

2. SOIL AND GROUNDWATER QUALITY ASSESSMENT

Two soil quality standards have been derived to assess soil and groundwater quality: i.e. the Target Value and Intervention Value (Fig. 1). Both standards are based on *potential* risks, i.e. the risk that would occur under "standardised" conditions: the Target Values on potential risks to ecosystems and the Intervention Values on potential risks to humans *and* ecosystems. Note that a different ecotoxicological risk *level* is used for derivation of Target vs. Intervention Values. A further criterion used is the non-risk-based Intermediate Value, which is simply the average of Target and Intervention Values. These are generic (i.e. independent of soil use) criteria:

From the site investigation the following implications can result:

- Concentration < Target Value (*clean soil*) means no restrictions.
- Concentration > Target Value and < Intermediate Value (*slightly contaminated soil/groundwater*) means no Further Investigation; (Minor) restrictions can be imposed on soil use.
- Concentration > Intermediate Value and < Intervention Value means starting with the Further Investigation. If this still results in soil/groundwater quality < Intervention Value, restrictions can be imposed on soil use. These are mainly based on other instruments than the Soil Protection Act (e.g.: no growth of sensitive food crops, no direct use of groundwater as drinking water).
- An average concentration in the porewater of a water-saturated soil volume of at least 100 m^3 > Intervention Value (*seriously contaminated groundwater*) means that in principle remediation will be necessary; the urgency of remediation has to be determined.

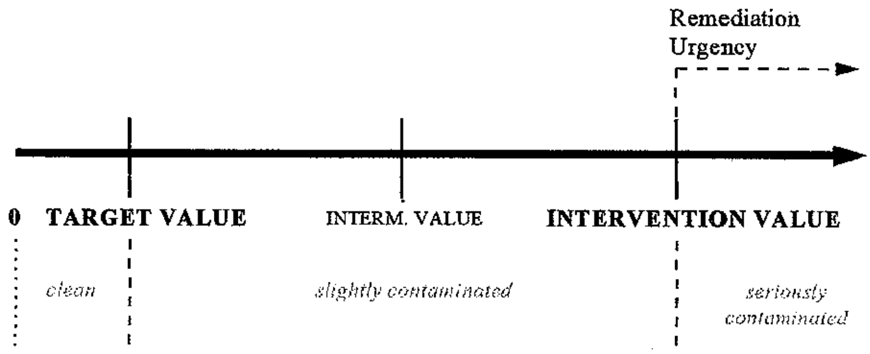


Fig. 1 Groundwater (and soil) quality standards and assessment

The purpose of determining the urgency of remediation is to distinguish between two urgency classes: urgent and non-urgent cases of serious groundwater contamination. For urgent cases remediation has to be initiated within one generation (circa 20 years). The determination of remediation urgency is based on *actual* (i.e. site-specific) risks to humans, ecosystems and risk due to contaminant migration. The procedure to determine the remediation urgency is described in Chapter 5.

3. TOOLS FOR SOIL QUALITY ASSESSMENT

3.1 HUMAN TOXICOLOGICAL RISK ASSESSMENT

Human exposure

Two human exposure models have been developed: CSOIL for exposure to contaminated terrestrial soils and SEDISOIL for exposure to contaminated sediments. Three elements are recognised in these models: contaminant distribution; contaminant transfer from (the different mobile phases of) the soil/sediment into contact media; direct and indirect exposure to humans. To enable assessment of exposure to contaminants in terrestrial soils the CSOIL calculation (Van den Berg, 1995) uses as starting-point the total soil concentration as representative soil content (Fig. 2).

The distribution over the mobile soil phases (pore water and soil gas) is calculated according to the fugacity theory of Mackay and Paterson (1981), using a standard soil, incl 10% organic matter, 25% clay and pH=6). In CSOIL formulae for the following exposure routes have been included in the model: soil ingestion; crop consumption; drinking-water intake; inhalation of air; inhalation of soil particles; inhalation of air during showering; dermal uptake via soil; dermal uptake during showering.

In the Netherlands there are many cases of groundwater contamination with volatile contaminants. The VOLASOIL model has been developed (Waitz et al, 1996), because the processes that determine the indoor air concentration are difficult to quantify, and the spatial and temporal variability of the indoor air concentration hampers accurate measuring. This model enables one to assess an indication of the *site-specific* indoor air concentration via a crawl space as a function of type and positioning of the contaminants, building and soil characteristics, and groundwater depth.

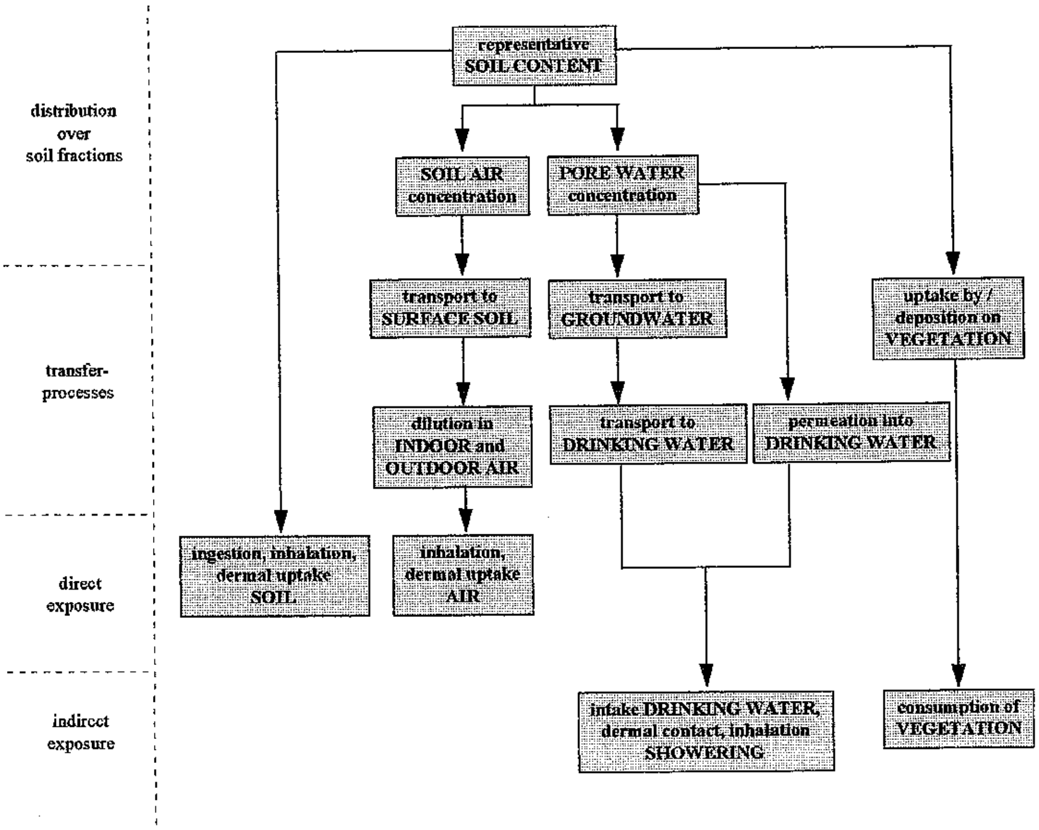


Fig. 2 CSOIL model to quantify exposure to contaminated terrestrial soils.

Tolerable exposure

A distinction has been made between non-threshold contaminants (*genotoxic carcinogens*) and threshold contaminants (*non-carcinogens and non-genotoxic carcinogens*)(Janssen and Speijers, 1997). For non-genotoxic carcinogens and non-carcinogenic contaminants, the toxicological Tolerable Daily Intake (TDI), as derived by the WHO, is taken as the Maximum Permissible Risk for intake (MPR_{human}). If no TDI is available, an Acceptable Daily Intake (ADI) is derived. A TDI or ADI is the threshold exposure of a contaminant to which humans can be orally exposed to daily on the basis of body weight without experiencing adverse effects on health. For genotoxic carcinogens, the MPR_{human} is defined as the dose of a contaminant (based on body weight for oral intake or air volume for inhalator intake) which forms a risk of one additional case of lethal tumour in 10,000 lifelong exposed individuals; this definition is based on a political decision (VROM, 1988). The values for MPR_{human} are given in Swartjes (1999).

3.2 ECOTOXICOLOGICAL RISK ASSESSMENT

Two relationships for each contaminant have been derived to quantify the ecotoxicological effects on ecosystems, i.e.:

- the relationship between soil concentration and irreparable damage to *terrestrial species composition* (Van Straalen and Denneman, 1989; Denneman and Van Gestel, 1990);
- the relationship between soil concentration and adverse effects on *microbial and enzymatic processes* (Crommentuijn et al., 1994).

The respective relationships are represented by the HCp-terrestrial species and HCp-processes (Hazardous Concentration functions, where 'p' represents the threatened percentage of the ecosystem). The relationships are derived on an empirical basis by statistical interpretation of observed NOECs (No Observed Effect Concentrations) and LOECs (Lowest Observed Effect Concentrations)(Aldenberg and Slob, 1993), assuming that the sensitivity of species in an ecosystem can be described by a statistical frequency distribution. If insufficiently data are available, L(E)Cs (Lethal Effect Concentrations) or aquatic data are used.

3.3 ASSESSMENT OF RISKS DUE TO CONTAMINANT MIGRATION

The assessment of contaminant migration in risk assessment has a special status because procedures to assess contaminant migration have, in contrast to assessment of risks to humans and ecosystems, been in use for many decades. To assess contaminant migration the following processes might play a role of importance: transport of water through aquifers (or soil); transport of gas through soil; retardation of the contaminants due to sorption onto solid-phase particles; (microbiological) degradation of contaminants; precipitation/ solution reactions; diffusion and dispersion in the (subsurface) soil and aquifer; fluid transport driven by density differences; preferential flow; contaminant uptake by crops, which reduces the contaminant load.

A (numerical) model can be used to assess the contaminant concentration at the location of a threatened target, combining (part of) the processes mentioned. The disadvantage of these models is that a large number of parameters have to be determined and expert knowledge on model application is required. A simple equation to indicate the risk due to contaminant migration might be used to enable application for a wide range of environmental scientists. An example of such an equation is based on the combination of the groundwater flow velocity of the water and contaminant retardation:

$$F = v/R \qquad (1)$$

where F = migration velocity of the contaminant (m/yr)
v = groundwater velocity (m/yr) (Darcy flux divided by effective porosity)
R = retardation factor (-).

Several methods exist to assess the soil/aquifer specific groundwater flow velocity, varying from monitoring to making a rough guess (expert judgement). The retardation factor can be determined by calculations based on the contaminant-specific sorption characteristics and the (subsurface) soil or aquifer. Using this simple equation results in a limited accuracy. For this reason it is wise to use more sophisticated procedures (models and/or monitoring systems) when in doubt about acceptable risks.

4. GROUNDWATER QUALITY STANDARDS

4.1 TARGET VALUES

The Target Values *for groundwater* are based on the Negligible Risk for aquatic ecosystems. This Negligible Risk level is assumed to be 1% of the Maximal Permissible Risk level for aquatic ecosystems (MPR_{eco})(VROM, 1988). This MPR_{eco} is defined as the HC5 (Hazardous Concentration for 5% of the species in the ecosystem), i.e. 95% protection. Using the relations described in section 3.2, the Target Value can be calculated as 1% of the HC5; no exposure to humans has been considered in the derivation of the Target Values. These Target values are independent of the soil type. However, because measured "natural" background concentrations *of metals* in groundwater are exceeding these risk-based values, the (measured) "natural" background concentrations are added to the risk-based concentration as described above. For the background metal concentration a difference has been made between deep (>10 m) and shallow groundwater (<10m), because in shallow groundwater background concentrations are often higher. For organic compounds the background concentrations are supposed to be negligible. When aquatic effect data for organic contaminants are lacking, the Target Values for groundwater for organic contaminants are based on other water quality standards or the detection limit. The Target Values for groundwater are given in Swartjes (1999).

4.2 INTERVENTION VALUES

The groundwater quality standards (Intervention Values groundwater), as incorporated in the Dutch Soil Protection Act, are derived from the quality standards for soil. For that reason first derivation of the Intervention Values for soil is described in this paper. The human toxicological and the ecotoxicological intervention values are integrated to yield the Intervention Value soil, after which the Intervention Value Groundwater is determined.

Human toxicological serious soil contamination

In agreement with "Premises for risk management"(VROM, 1988), the human toxicological definition for serious soil contamination is taken as the soil quality resulting in exceeding of the Maximum Permissible Risk for intake (MPR_{human}). For this reason, the human toxicological intervention value is defined as the concentration of a contaminant in the soil which would result in an exposure equal to the MPR_{human} under standardised conditions (*potential* exposure), see Fig. 3.

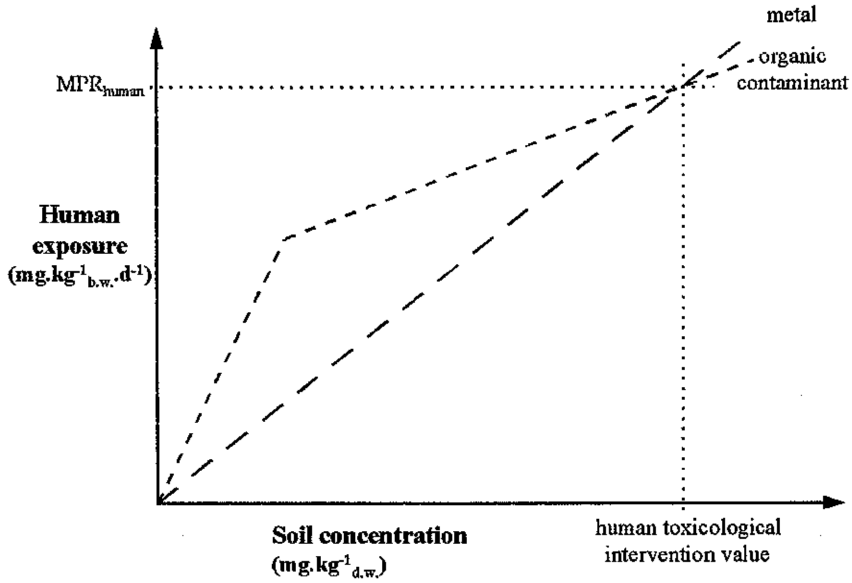


Fig. 3 Derivation of the human toxicological intervention value

The potential exposure is calculated using the CSOIL model. A standard exposure scenario has been defined to describe the standardised conditions (Van den Berg, 1995). In this scenario 'residential with garden' all exposure pathways in CSOIL (section 3.1) are assumed to be operational. In case that the calculated indoor air concentration (an intermediate result) exceeds the Tolerable Concentration Air (TCA), the human toxicological intervention value for soil is corrected in such a way that the calculated indoor air concentration equals the TCA. In the next step the exposure from all pathways is calculated for children and adults separately. Finally, the mean lifelong exposure is calculated. Soil ingestion, crop consumption and inhalation of air generally contribute at least 90% to the total exposure for all contaminants.

Ecotoxicological serious soil contamination

The ecotoxicological intervention value has been defined as the HC50 (Hazardous Concentration 50, i.e. 50% of the ecosystem threatened; see section 3.2). This risk level is much less stringent than the MPR_{eco}, which is defined as the HC5. The reason for this is a compromise between ecological acceptance (if 50% is protected the chance for recovery is acceptable) and practical use (the resulting contaminant concentrations in soil are high enough to avoid a huge part of the Netherlands being tagged as seriously contaminated). The extent of the adverse effects will vary among species and range from negligible to severe. An implication of this is that sensitive species are not protected at the level of the (ecotoxicological) intervention value.

Intervention Value for soil

The same weight is given to human as to ecotoxicological protection. This means that the most stringent (i.e. the lowest) value of the human toxicological and the ecotoxicological intervention values is taken as 'the' Intervention Value. An exception is made if the lower value is much more uncertain, in which case, the higher, but more reliable value, is taken as the final Intervention Value. It has been assumed that this is the case when one value is classified as "low" and the other as "high". For this purpose an uncertainty score has been assigned to the human toxicological and ecotoxicological intervention values.

The Intervention Values (applicable to a 'standard' soil of 10% organic matter and 25% clay) are corrected for organic matter and clay content (Van den Berg et al, 1993), and in doing so, indicate a correction for (bio-)availability.

Intervention Value for groundwater

The Intervention Value for groundwater has been derived from the Intervention Value for soil and is independent of the soil characteristics (e.g. organic matter and clay content). The Intervention Value for groundwater is defined as the concentration in groundwater that is related to a soil concentration that equals the Intervention Value. It is calculated on the basis of both the partitioning between the solid phase and pore water, and leaching into the groundwater. First the equilibrium concentration in the pore water is calculated by dividing the Intervention Values for soil by an (average) partition coefficient (Van den Berg and Roels, 1991). The equilibrium concentration in the groundwater is calculated by simply dividing the pore water concentration by a factor of 10, taking into account the uncertainty in the partition coefficient, lack of partitioning equilibrium, dilution processes and the heterogeneity of the leaching process. The derivation with this factor must be seen as a generic approach to estimate the groundwater concentration based on the porewater concentration and to be able to detect soil pollution bases on compounds in the groundwater. Degradation has not been taken into account.

Secondly the possible consumption of contaminated groundwater as drinking water has been considered. When using (contaminated) groundwater directly as drinking water results in unacceptable human exposure (i.e. exposure exceeds the MPR_{human}), the Intervention Value for groundwater is corrected in such a way that drinking this contaminated groundwater would result in an exposure equal to the MPR_{human}.

Finally, the Intervention Values for groundwater were compared to existing quality objectives for soil and groundwater (VROM, 1991), and with data generally representative of the groundwater in the Netherlands (data for relatively "clean" groundwater from the Dutch National Groundwater Quality Monitoring Network).

The Intervention Values for groundwater are given in Swartjes (1999).

5. PROCEDURE TO DETERMINE REMEDIATION URGENCY

One main difference with the procedure used to derive generic soil and groundwater quality guidelines is that determination of the remediation urgency is based on *actual* risks. The actual risk focuses on the site-specific risks, now and in the (near) future. This risk analysis is based on risk to humans, to the ecosystem and on the risk due to contaminant migration (i.e. migration of the contaminants from a contaminated site to other targets). The methodology is conservative, meaning that actual risks are assumed, unless it can be proved otherwise. The methodology has been incorporated in the computer package *SUS* (Urgency of Remediation Methodology).

Actual risk for humans

At the contaminated site, the actual exposure of humans has to be quantified. The exposure model CSOIL and VOLASOIL (to calculate the site-specific indoor air quality) can be used for contaminated groundwater and terrestrial soil. However, because of large uncertainties, calculations have, in most cases, to be combined with measurements in contact media (contaminant concentration in indoor air or soil air).

Actual risk for ecosystems

Because there are no exposure models in use for assessing the risk for ecosystems, a pragmatic procedure has been developed to account for actual risks to ecosystems (Notenboom et al., 1995). In this procedure a matrix has been defined on the basis of two elements: Degree of contamination: soil concentration < 10*HC50 or soil concentration > 10*HC50 (two classes); Ecological "sensitivity" of the area (three classes). If this simple procedure does not result in a clear decision on the actual risk, performing measurements (bio-assays) is recommended.

Actual risk due to contaminant migration

For groundwater an important criterion in determining the urgency of a contaminated site is the risk of contaminant migration. To enable uniform assessment applicable for a wide range of environmental scientists, a rather simple procedure has been adapted to determine the actual risk due to groundwater contamination (Swartjes et al., 1994). This procedure is based on the stand-still principle: contaminants should not move independently of the targets that may be threatened. For this purpose the simple equation (Eq. 1) given in section 3.3 is used to quantify the migration velocity of the contaminant. Multiplication of this migration velocity by the largest cross-section of the contaminant plume in the saturated zone gives the flux of the contaminant, Fd (m^3/yr):

$$Fd = (v / R) * A$$

where A = largest cross-section of the contaminant plume (m^2);

R = retardation factor, $R = 1 + (\rho * K_d) / \theta$ (-).

where ρ= specific density of soil (kg/dm^3); K_d= partition coefficient soil/water (dm^3/kg) and; θ= water content (m^3/m^3).

The contaminant flux represents the increase in the volume of contaminated groundwater. The criterion, increase in a volume of contaminated water-saturated soil of more than 100 m^3 within the period of one year, is used for actual risk due to contaminant migration. Besides, the total contaminant load within a year should be sufficient to contaminate the groundwater in a volume of 100 m^3 water-saturated soil up to the level of the Intervention Value for groundwater. In other words, no extra cases of serious soil contamination (see section 4.2) should develop within a year. If this simple procedure does not result in a clear decision on the actual risk due to contaminant migration, application of (numerical) models and/or monitoring is recommended.

Monitoring is used to mark out the Intervention Value contour of a groundwater contamination. Together with data on the position of the original source and the last year of emissions to the soil, the velocity of the contaminant migration can be estimated. These data also can be used in further model calculations of contaminant migration.

6. EVALUATION OF THE INTERVENTION VALUES

The first series of Intervention Values was formalised in 1994 (VROM ,1994). Since then new insights into the risk assessment procedures and new data have become available and lessons were learned from the application of Intervention Values. For that reason an evaluation of the current Intervention Values for soil and groundwater has been started in 1998, to be completed in 2000. In this evaluation the procedures as well as all (important) data used are being reviewed. For the derivation of the Intervention Value groundwater a modified procedure is considered. The following elements as the bases of the Intervention Value groundwater are proposed:

potential exposure of humans to the contaminants in groundwater, 1. by direct consumption of groundwater as drinking water and/or 2. by exposure to contaminants migrating from groundwater into air, plants or drinking water.

- ecotoxicological risks of contaminants to groundwater organisms, as has been worked out for pesticides in Notenboom et al (1999); due to the limited data on these organisms and in line with toxicity to terrestrial species the HC50 of freshwater organisms is proposed.

- partitioning with and leaching from contaminated soil; equilibrium partitioning and the application of a factor 10 between the concentration in the porewater (in equilibrium with the soil content) and groundwater is evaluated;
- potential direct of indirect exposure of live stock and potential effects on agricultural crops.

All the mentioned data will be reported, after which in the end of 2000 the Dutch Government decides what procedure is implemented.

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11. Groundwater Quality Standards in Germany

Lutz Haamann, Degussa-Hüls AG

GROUNDWATER QUALITY STANDARDS IN GERMANY

Lutz Haamann, Degussa-Huels AG

ABSTRACT

According to the Federal Water Act of Germany, groundwater is protected against all alterations, chemical or physical. But there are no binding limits for the evaluation of groundwater. Very recently there is a Federal Soil Protection Act, which has substantial influence on the evaluation of brownfields including groundwater. The drinking water regulation of Germany is not based on the Water Act but on the food legislation. This regulation is often used as criterion for groundwater quality.

Each State in Germany („Laender") has its own Water Act, based on the Federal Water Act. There are considerable differences between the orientation values of the states and there are different approaches on how to apply orientation values. Due to the differences between the environmental standards of the States a working group with participation of all States published 1994 a paper called „Recommendations for the Investigation, Evaluation and Remediation of Groundwater Contamination" which is today widely used as a quality standard for groundwater in Germany. It has the character of a consensus paper but it is not an act or binding regulation. Key points are: with respect to financial budgets and technical feasibility not all contaminations must be cleaned up completely, immediately and simultaneously. The protection of drinking-water resources has the highest priority. Important ecosystems have equal priority. Damage to property has lower priority. Each case of groundwater contamination has to be evaluated individually.The authorities have margin of discretion. Local conditions of hydrogeology influence the evaluation greatly. Orientation values are listed for key substances.

INTRODUCTION

The title of the 20th International Association of Hydrogeologists / Irish Group Seminar is „Groundwater and the Law". For two reasons, this title gives us grounds for optimism:

<u>Firstly</u>, it gives the feeling that we geologists are not outlaws, although some lawyers sometimes seem to hold this view, especially when geologists have to explain that each case of groundwater-contamination has its own rules.

<u>Secondly</u>, and more seriously, it indicates a broad consensus that good legislation is at least as important for groundwater protection, as scientific research and technical development. And certainly most of us agree, that so called „legal remediation" is not the solution to environmental problems.

SURVEY OF GERMAN WATER LEGISLATION

Let me start with an overview on German water laws. This overview is very incomplete, but it should cover the most important parts of the water legislation usually needed for the discussion about brownfield sites in Germany.

You probably know that Germany is a Federal Republic. This means, that we have federal legislation and state legislation. Criminal Acts or Tax Acts for example are federal law, Building Acts are, for example, state law. The Water Act, similiar to other environmental acts, is a mixture: There is a federal law which gives the framework and which gives the right to the states to make their regulations. Each state has its own Water Act, but in practice, these are quite similar to each other.

FEDERAL LAWS AND REGULATIONS

The Federal Water Act

According to the Federal Water Act, groundwater is generally protected against all alterations, chemical or physical. As a general rule, the legislation assumes that groundwater shall be used as drinking water. In practice that means that often the Drinking Water Regulation is used as a quality standard for groundwater. But the limits of the German Drinking Water Regulation, similiar to the EC Directive on Drinking Water, are intended for application at the consumers' location. In many cases it makes no sense to use them as remediation targets for contaminated aquifers.

To say it very clearly: There are no general, binding limits for the evaluation of groundwater in Germany.

The Federal Soil Protection Act

Very recently, a Federal Soil Protection Act was enacted in Germany, which has substantial influence on the evaluation of brownfield sites, including groundwater. The technical rules under this Act describe the general procedure for investigation, evaluation, and remediation of brownfields. Orientation values for soil and soil extracts are given for the evaluation of the potential impact of soil contaminations to the groundwater.

Drinking Water Regulation

The drinking water regulation of Germany is not based on the Water Act, but on the food legislation. As mentioned before, this regulation is nevertheless often used as „ultimate" criteria for groundwater quality. The drinking water regulation contains a broad catalogue of limits for biological, chemical and physical parameters. It is written primarily for to the suppliers of drinking water. They have to monitor their product drinking water at well defined transfer points from their distribution system to the consumer. The methods how to do this and the limits are given within the regulation.

Practically, the water supplying organisations use the limits of the Drinking Water Regulation as criteria for the quality of their water collecting area. Contaminations of an aquifer within this area above these limits are not acceptable.

STATE LAWS AND REGULATIONS

State Water Acts

Each German State (the „Laender") has its own Water Act. In addition, the environmental authorities of each state created different „lists" of orientation values for groundwater quality, which are often based on the Drinking Water Regulation or on other regulations like the well-known Dutch list. There are considerable differences between the orientation values of the States. And, even worse, we have different approaches on the application of orientation values. You might find in Germany state authorities which are using lists similiar to law and you may find those who use the professional judgement for every single case and use lists only for orientation purposes.

Protection areas for groundwater

The Federal Water Act gives the States the right to define protected areas for the drinking water supply. Each State has a paragraph about the protection of drinking water areas within its State Water Act. Professional associations have given technical advice on how to define those areas with several published papers. The water suppliers have to apply for such areas and the authorities have to issue a permit. Once such an area is fixed, it has a strong legal position, comparable with a regulation.

The general concept is to have three zones with different levels of protection around the wells.

Zone III is the widest area. It should include generally the whole catchment area.
Zone II is more narrow. It is defined as a line around the wells in a distance equivalent to the distance of 50 days of groundwater flow.
Zone I is generally the fenced area of 20 or 30 meters around the well.

In calculating the zones, the geological conditions of the area are extremely important, as the horizontal flow within the aquifer as well as the vertical flow of infiltration have to be considered.

WORKING GROUP OF THE STATES WITH PROPOSALS FOR ORIENTATION VALUES (ADMINISTRATIVE PROVISIONS)

Due to difficulties caused by the different environmental standards of the States, the environmental chamber of the Bundesrat, which is the common legislative institution of the States, decided at the beginning of the Nineties to install working groups with participation of professionals from all States. One of those working groups dealt with water issues while others were for waste and for soil.

The water working group succeeded finally in 1994 in publishing a paper called „Recommendations for the Investigation, Evaluation and Remediation of Groundwater Contamination". It is a short paper of less than 20 pages and an annex with tables of orientation values.

This paper is widely used in Germany as standard for the evaluation of groundwater quality. It has the character of a consensus paper but it is not an Act or binding regulation.

Key issues of this paper are:

- The objective for ground water according to the Federal Water Act must be: Remediation for all groundwater contaminations. However, due to restricted financial budgets and technical feasibility, not all contaminations must be cleaned up completely, immediately and at the same time.
  The protection of drinking-water resources has highest priority. Important ecosystems have equal priority. Damage to property has lower priority.
- Each case of groundwater contamination has to be evaluated individually.The authorities have a margin of discretion. Local conditions of hydrogeology greatly influence the decision about necessity, time and targets of a remediation plan.
- There are no binding limits for substances given. Orientation values are listed for key substances.
- There are two kinds of orientation values:

  Examination values: If those are exceeded, further investigations are necessary. If not, generally no relevant contamination is to be expected and further action is not necessary.

  Action Values: If those values are exceeded, protection measures or remediation actions are usually necessary.

- There are three tables with orientation values published, which are attached to this paper as an annex:

  Table 1 gives examination values for the basic parameters of the groundwater analysis.

  Table 2 gives examination values and action values for some key parameters for contamination.

  Table 3 gives orientation values for soil. Those values are enclosed to give orientation about the potential impact of soil contaminations to the groundwater.

Let us take a closer look at table 2, which is most commonly used in practice for the evaluation of groundwater contaminations:

You see the parameters, the unit, a range of examination values and a range of action values. For the examination values, the upper value of the range is derived from the long-term toxicological value (e.g. limit for drinking water) and the lower is derived from the geogenic or anthropogenic background. The range of the action value is derived from the range of long-term toxicological values with respect to the relationship between dose and effect.

Let us have a look at cadmium within the list as an example:

> The groundwater analysis shows mostly values between 1 and 5 µg/l; some values might be slightly above or below this range. An important question is whether natural conditions exist with higher cadmium levels. For example, some metal-bearing layers within the aquifer? Is there a general anthropogenic elevation, for example through widespread use of fertilisers? If there is a plausible explanation the process may be finished. If not, authorities may ask for further investigations and for identification of a source.
>
> The groundwater analysis shows mostly values between 10 and 20 µg/l for Cadmium, some values might be slightly above or below this range. This normal indicates that there is a contamination source. The source must be identified. The evaluation process then will show what kind of remediation or protection is necessary. The range of measures might be from further long-term monitoring of the aquifer, to pump-and-treat measures or complete excavation of a point source. This decision is frequently the subject of negotiation between the party who would have to pay for the measures and the authorities. In practical terms, the most important questions for this decision are: Is there any use for the contaminated water? Is to be expected, that the situation will become worse in future, or is there a time-dependent natural attenuation process? And, last but not least, is there any money for remediation available?

CONTRACT WITH AUTHORITIES ABOUT REMEDIATION TARGETS

As mentioned at the beginning, the German Water Act generally protects groundwater with the objective of returning it to its natural condition. It is theoretically not legal to accept a groundwater contamination as status quo. The authority may decide that, after spending a lot of money, remediation action may be stopped before the natural level has been approached, but the authority theoretically may decide as well, that action has to go on for many years. Or it may decide after some years to start remediation again. For many brownfields this unreliable legal status prevents the beginning of remediation or new investment. Nobody wants to start spending money if he does not know how much it will be at the end of the day.

More often today private companies and authorities negotiate contracts for remediation actions. Within such a contract there is generally an action programme for remediation defined, which must be conducted by the private company. The authorities, representing the public interest, agree on the other hand to accept a remediation target which is not as restrictive as the Water Act requires. Practical remediation targets for such a contract might for example be that 90% of contamination has to be eliminated or that action can be stopped if the efficiency of removal is lower then a defined degree. The advantage for the private company is, that it can now calculate the costs of the action. The advantage for the public is, that more remediation actions are started. There is generally a low risk, that after a successfully completed remediation action, further remediation has to be payed for by the public due to requirements of the Water Act.

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ANNEX

Tabelle 1: Prüfwerte für Basisparameter zur Vor- und Hauptuntersuchung von Grundwasser

Parameter	Einheit	Mindeständerung im Vergleich zum Oberstrom (Differenzwert)	Voruntersuchung 7)
Färbung (visuell) 1)		Verfärbung	+
Trübung (visuell) 1)		Eintrübung	+
Geruch (qualitativ) 1)		deutlicher Fremdgeruch	+
Temperatur (t)1))		deutliche Änderung	+
Leitfähigkeit (bei 20 °C) 1)	µS/cm	+ 200 3)	+
pH-Wert (bei t) 1)		± 0,3 bis 1,0 4)	+
Calcitlösekapazität (CaCO3)	Mg/l	deutliche Änderung	
Säurekapazität bis pH 4,3 (KS 4,3)	mmol/l	± 1 3)	+
Basekapazität bis pH 8,2 (KB 8,2)	mmol/l	± 0,5	+
Sauerstoff, gelöst (O2) 1)	mg/l	- 3	+
Calcium (Ca2+)	mg/l	+ 20 3)	+
Magnesium (Mg2+)	mg/l	+ 10 3)	+
Natrium (Na+)	mg/l	+ 20 3)	
Kalium (K+)	mg/l	+ 10 3)	
Mangan, gesamt (Mn)	mg/l	deutliche Änderung	
Eisen, gesamt (Fe)	mg/l	deutliche Änderung	
Ammonium (NH4+)	mg/l	+ 0,3 5)	+
Chlorid (Cl-)	mg/l	+ 30 3)	+
Sulfat (SO42-)	mg/l	± 30 6) 3)	+
Nitrat (NO3-)	mg/l	± 10	+
Nitrit (NO2-)	mg/l	+ 0,3	
Phosphat, ortho (PO43-)	mg/l	+ 0,2	
Kieselsäure (SiO2)	mg/l	+ 10	
Oxidierbarkeit (Permanganatindex) (O2)	mg/l	+ 3 5)	+
Gel. organisch geb. Kohlenstoff (DOC)	mg/l	+ 4 5)	+
Spektr. Absorptionskoeffizient 436 nm	m^{-1}	+ 5	
Spektr. Absorptionskoeffizient 254 nm	m^{-1}	+ 5	
Leichtflüchtige Halogenkohlenwasser stoffe (LHKW, gesamt)-	µg/l	+ 5 5)	+
Adsorbierbare org. geb. Halogene (AOX)	µg/l	+ 20 5)	+
Bor (B)	mg/l	+ 0,1	+
Biotest (Daphnien- oderLeuchtbakterientest)		Toxische Wirkung im unverdünnten Grund- wasser	
Koloniezahl	1/ml	deutliche Änderung	

1) Bestimmung bei der Probenahme vor Ort
2) Bei Grundwassertemperaturänderungen sind ggf. die Einflüsse von Bauwerksgründungen und Oberflächenwasserinfiltration zu berücksichtigen.
3) In einigen Grundwasserleitern liegt aufgrund der geogenen Grundbelastung die natürliche Schwankungsbreite in der o. a. Größenordnung.
4) pH-Änderungen sind in Zusammenhang mit dem Pufferungsvermögen des Wassers zu bewerten.

5) Bei höherer Vorbelastung: + 25 %
6) Bewertung einer Konzentrationsabnahme nur unter der Voraussetzung, daß auch eine Denitrifikation stattgefunden hat
7) Im Rahmen der Voruntersuchung ist primär auf die mit + gekennzeichneten Parameter zu untersuchen.

Tabelle 2: Prüf- und Maßnahmenschwellenwerte für einige Leitparameter der Hauptuntersuchung von Grundwasser

Parameter	Einheit	Prüfwert	Maßnahmen-schwellenwert
Antimon (Sb)	µg/l	2 - 10	20 - 60
Arsen (As)	µg/l	2 - 10	20 - 60
Barium (Ba)	µg/l	100 - 200	400 - 600
Blei (Pb)	µg/l	10 - 40	80 - 200
Cadmium (Cd)	µg/l	1 - 5	10 - 20
Chrom, gesamt (Cr)	µg/l	10 - 50	100 - 250
Chrom VI (Cr)	µg/l	5 - 20	30 - 40
Kobalt (Co)	µg/l	20 – 50	100 - 250
Kupfer (Cu)	µg/l	20 - 50	100 - 250
Molybdän (Mo)	µg/l	20 - 50	100 - 250
Nickel (Ni)	µg/l	15 - 50	100 - 250
Quecksilber (Hg)	µg/l	0,5 - 1	2 - 5
Selen (Se)	µg/l	5 - 10	20 - 60
Zink (Zn)	µg/l	100 - 300	500 - 2000
Zinn (Sn)	µg/l	10 - 40	80 - 200
Cyanid, gesamt (CN-)	µg/l	30 - 50	100 - 250
Cyanid, frei (CN-)	µg/l	5 - 10	20 - 50
Fluorid (F-)	µg/l	500 - 1500	2000 - 3000
PAK, gesamt 1)	µg/l	0,1 - 0,2	0,4 - 2
- Naphthalin als Einzelstoff	µg/l	1 - 2	4 - 10
LHKW, gesamt 2)	µg/l	2 - 10	20 - 50
- Summe LHKW, karzinogen 3)	µg/l	1 - 3	5 - 15
PBSM, gesamt 4)	µg/l	0,1 - 0,5	1 - 3
PCB, gesamt 5)	µg/l	0,1 - 0,5	1 - 3
Kohlenwasserstoffe 6) (außer Aromaten)	µg/l	100 - 200	400 - 1000
BTX-Aromaten, gesamt 7)	µg/l	10 - 30	50 - 120
- Benzol als Einzelstoff	µg/l	1 - 3	5 - 10
Phenole, wasserdampf-flüchtig	µg/l	10 - 20	30 - 100
Chlorphenole, gesamt 8)	µg/l	0,5 - 1	2 - 5
Chlorbenzole, gesamt 8)	µg/l	0,5 - 1	2 - 5

1) PAK, gesamt: Summe der polycyclischen aromatischen Kohlenwasserstoffe, in der Regel Summe von 16 Einzelsubstanzen nach der Liste der US Environmental Protection Agency (EPA) ohne Naphthalin; ggf. unter Berücksichtigung weiterer relevanter Einzelstoffe (z. B. Methylnaphthaline)
2) LHKW, gesamt: Leichtflüchtige Halogenkohlenwasserstoffe, d. h. Summe der halogenierten C1- und C2-Kohlenwasserstoffe
3) Summe LHKW, karzinogen: besondere Festlegung für die Summe der erwiesenermaßen karzinogenen LHKW Tetrachlormethan (CCl_4), Chlorethen (Vinylchlorid, C_2H_3Cl) und1,2-Dichlorethan
4) PBSM, gesamt: Organisch-chemische Stoffe zur Pflanzenbehandlung und Schädlingsbekämpfung einschließlich ihrer toxischen Hauptabbauprodukte

5) PCB, gesamt: Summe der polychlorierten Biphenyle; in der Regel 6 Kongenere nach Ballschmiter (bzw. Altöl-VO), ggf. unter Berücksichtigung weiterer relevanter Einzelstoffe
6) Bestimmung mittels IR-Spektroskopie nach DIN 38409-H18
7) BTX-Aromaten, gesamt: Leichtflüchtige aromatische Kohlenwasserstoffe (Benzol, Toluol, Xylole, Ethylbenzol, Styrol, Cumol etc.); besondere Festlegung für Benzol
8) Wenn ein PBSM (z. B. PCP, HCB) oder ein Abbauprodukt eines PBSM vorliegt, dann gelten die o. a. Prüf- bzw. Sanierungsschwellenwerte für PBSM

Tabelle 3: Orientierungswerte für Bodenbelastungen

Parameter	Einheit	Prüfwert	Maßnahmen-schwellenwert
PAK, gesamt 1)	mg/kg	2 – 10	10 - 100
- Naphthalin als Einzelstoff	mg/kg	1 – 2	5
LHKW, gesamt 2)	mg/kg	1 – 5	5 - 25
- S LHKW, karzinogen 3)	mg/kg	0,1 – 1	0,1 - 5
LHKW, gesamt 2) - in der Bodenluft 7)	mg/m3	5 - 10	50
PCB, gesamt 4)	mg/kg	0,1 - 1	1 - 10
Kohlenwasserstoffe 5) (außer Aromaten)	mg/kg	300 - 1000	1000 - 5000
BTX-Aromaten, gesamt 6) 7)	mg/kg	2 – 10	10 - 30
- Benzol als Einzelstoff	mg/kg	0,1 - 0,5	0,5 - 3
Phenole, wasserdampfflüchtig	mg/kg	1 - 10	10 - 25
Chlorphenole, gesamt	mg/kg	1 - 5	5 - 10
Chlorbenzole, gesamt	mg/kg	1 - 5	5 - 10

1) PAK, gesamt: Summe der polycyclischen aromatischen Kohlenwasserstoffe, in der Regel Summe von 16 Einzelsubstanzen nach der Liste der US Environmental Protection Agency (EPA) ohne Naphthalin; ggf. unter Berücksichtigung weiterer relevanter Einzelstoffe (z. B. Methylnaphthaline)
2) LHKW, gesamt: Leichtflüchtige Halogenkohlenwasserstoffe, d. h. Summe der halogenierten C1- und C2-Kohlenwasserstoffe
3) Summe LHKW, karzinogen: besondere Festlegung für die Summe der erwiesenermaßen karzinogenen LHKW Tetrachlormethan (CCl4), Chlorethen (Vinylchlorid, C2H3Cl) und 1,2-Dichlorethan
4) PCB, gesamt: Summe der polychlorierten Biphenyle; in der Regel 6 Kongenere nach Ballschmiter (bzw. Altöl-VO), ggf. unter Berücksichtigung weiterer relevanter Einzelstoffe
5) Bestimmung mittels IR-Spektroskopie nach DIN 38409-H18
6) BTX-Aromaten, gesamt: Leichtflüchtige aromatische Kohlenwasserstoffe (Benzol, Toluol, Xylole, Ethylbenzol, Styrol, Cumol etc.); besondere Festlegung für Benzol
7) Die Orientierungswerte für LHKW in der Bodenluft können mit Einschränkung auch für die Beurteilung von Belastungen mit leichtflüchtigen BTX-Aromaten herangezogen werden.

12.* Contaminated Land: Groundwater Quality Standards in the UK

Barry Smith, British Geological Survey

13. Proposed Groundwater Quality Standards for Ireland

M. Keegan, G. O'Leary, and G. Carty, Environmental Protection Agency

THE DEVELOPMENT OF GUIDELINE AND INTERVENTION VALUES FOR THE PROTECTION OF GROUNDWATERS IN IRELAND

Margaret Keegan, Gerard O'Leary and Gerry Carty , Environmental Protection Agency.

Abstract

In Ireland in the absence of national guideline and intervention values, consultants, local authorities and others have used a variety of international groundwater criteria to assess groundwater quality. The Environmental Protection Agency (EPA) recognises the need for a uniform approach, which would have regard to the pressures on groundwater. Such pressures include domestic, agricultural and industrial discharges.In late 1999 the EPA commenced work to develop guideline values which would form part of a methodology to assess groundwater quality. The work includes a review of International policy, practice and guideline/intervention values. The review would inform the development of guideline and intervention values for the protection of groundwater in Ireland. This project is ongoing and this paper presents some preliminary findings.

INTRODUCTION

Section 75 of the EPA Act, 1992, permits the EPA to specify and publish Environmental Quality Objectives (EQOs) *"which the Agency considers reasonable and desirable for the purpose of environmental protection"*. The EPA published a draft EQO/EQS publication on the aquatic environment in 1999. This publication proposes values for the protection of surface waters and while many of the same concentrations apply to groundwaters it did not address the specific parameters or values appropriate to groundwaters, consequently groundwater does not fall within the scope of this document.

Currently Irish drinking water standards are used to assess groundwater quality. These drinking water standards apply to treated water at the tap or water at the point of consumption. Guideline and intervention values from the UK (ICRCL), the Netherlands and other countries have been used as clean up standards in Ireland in recent years. The EPA is considering the appropriateness of these standards for groundwater in Ireland.

The EPA is responsible for licensing of scheduled waste and industrial activities. Groundwater protection is of paramount importance when applying for a Waste or an IPC licence. Section 40(4) (a) of the Waste Management Act 1996, does not allow the Agency to grant a licence unless it is satisfied that any emission from the activity will not contravene any relevant standard or any relevant emission standard. Similar restrictions apply under the EPA Act, 1992. The EPA has published detailed waste licensing application guidelines with respect to hydrogeological aspects of the existing environment and hydrogeological impacts/mitigation measures.

Against this backdrop the Agency intend to develop guideline values for the protection of groundwaters. Following a competitive tendering process the EPA awarded a contract to Dames and Moore in December 1999, to review international groundwater guideline/intervention values and to develop guideline values which would form part of a draft methodology to assess groundwater quality.

This contract is divided into three tasks (see Box 1).

Box 1.

> TASK 1: Review of existing groundwater situation in Ireland and of best international practice in relation to groundwater protection.
>
> TASK 2: Review of International policies and guideline/intervention values.
>
> TASK 3: Recommendations for the setting of Irish guideline/intervention values.

The main deliverables from the project are:

- A listing of contaminants that may pose a risk to Irish groundwaters from sectors including agriculture, waste activities and industry and which need to be controlled in order to protect Irish groundwaters;
- A summary of policies and interpretation of groundwater guideline/intervention values from the following countries; Canada, Denmark, Netherlands, New Zealand, Switzerland, UK and the USA;
- Criteria and methodology to be used for the setting of guideline/intervention values (i.e. parametric values) for Ireland; and
- A recommended list of draft guideline/intervention values for Ireland.

REVIEW OF THE EXISTING GROUNDWATER SITUATION IN IRELAND

Groundwater is an important water resource in the Republic of Ireland and it accounts for up to 15% of total water supplied by local authorities and about 25% of all water supplies (Daly 1993, EPA 1999). Only a small proportion of the available groundwater resource is currently being used. Hence, there is potential for increased usage in the future. A very large number of groundwater supply sources exist, Wright (1999) estimates that there are at least 200,000 wells in the country. As well as providing potable water supplies, groundwater is an important source of water for food processing industries, creameries, meat factories and bottled waters. In addition, groundwater plays a key role in the hydrological cycle in terms of its baseflow contribution to rivers and in maintaining wetland habitats.

The quality of groundwater is assessed through different monitoring programmes for drinking water supplies, licensed activities, and the EPA national groundwater programme. The quality in Ireland is generally good. *Nitrate* contamination is not widespread and is generally observed in low yielding wells and in close proximity to waste sources such as silage and slurry pits. *Phosphorous (P)* is not a problem in groundwater however it may act as a pathway for P to receptors such as lakes, streams and wetlands. *Trace metals* are generally found at low levels owing to their low solubilities at normal groundwater pH values. However, iron (Fe) and manganese (Mn) can occur at elevated levels in certain natural hydrogeological conditions, or where organic pollution has resulted in deoxygenation of the water. Trace organic contamination in groundwater was found to occur in close proximity to point sources (Cullen, 1994).

The EPA groundwater results (EPA 1999) and earlier studies (e.g. Daly, D. 1994, Daly and Wood 1995) indicate that the main groundwater quality problems are associated with local microbiological contaminants rather than chemical contamination. In practice, faecal coliforms (e.g. *E. Coli*) are the main microbiological contamination indicators analysed but other microbiological contaminants could be significant (e.g. viruses and cryptosporidium). The widespread occurrence of coliform contamination is a significant concern. In general the majority of private groundwater supplies do not undergo any treatment prior to use.

The 'Groundwater Protection Schemes' document (DELG/EPA/GSI 1999) identified the following pressures on groundwater in Ireland:

- widespread application of domestic, agricultural and industrial effluents to the ground;
- the increase in domestic and industrial wastes, and landfill is the principal disposal route;
- significant increase in the application of inorganic fertilisers to agricultural land;
- increased pesticide usage;
- road traffic and storage of fuels/chemicals;
- chemicals of increasing diversity and often high toxicity are being manufactured, distributed and used for a wide range of purposes.

The pressures imposed on groundwater by each of the above will depend to a great extent on the groundwater vulnerability.

Increased usage of groundwater is likely as domestic and industrial demand expands in areas with limited surface waters. This will heighten the need for aquifer protection and the treatment of groundwater to ensure that the quality of drinking water will conform to the requirements of the Drinking Water Regulations (SI No. 350 of 1999). The Groundwater Protection Schemes document launched by the DELG/EPA/GSI in 1999 will assist in the protection of aquifers but guideline and intervention values are also required. A prioritised listing is presently being prepared and will have regard to the pressures on groundwater and the role groundwater plays in the complete water cycle.

INTERNATIONAL REVIEW

The international review examined policy, practices and standards used in the following countries:

- Canada
- Denmark
- Netherlands
- New Zealand
- Switzerland
- UK
- USA

The review for each country examined the following aspects:

- Groundwater protection - policy;
- Groundwater protection - practice;
- Numeric assessment criteria; which is subdivided into derivation basis (including the use of risk assessment in the development of groundwater values, including the source-pathway-target concept);
- Applicability to Ireland; and
- Sampling and analytical issues.

The review has identified a number of issues important in the development of guidance for the protection of groundwater. These issues include:

- Groundwater is a common source of supply for human consumption;
- Groundwater provides baseflow to surface water bodies; and
- Groundwater quality can be compromised by a host of point and diffuse contamination sources.

In summary the international review indicated that:

- The Netherlands is the only country that has developed criteria specifically for assessing groundwater contamination;
- Drinking water criteria are used by all other countries;
- Criteria set for the protection of specific receptors (e.g., aquatic life, crop irrigation and livestock watering) are commonly used;
- Risk assessment is used in all countries, except Denmark.

This information is summarised in the following Table 1.

Table 1.

Country	% drinking water supplied from groundwater	Criteria used to assess groundwater contamination 1	2	3	4	5	Risk assessment allowed/used
Canada	25% overall up to 82% in rural areas		◆	◆	◆	◆	◆
Denmark	95% overall		◆				
Netherlands	80% overall	◆					◆
New Zealand	40% overall		◆	◆	◆	◆	◆
Switzerland	83% overall		◆				◆
USA	53% overall		◆				◆
UK	68% overall		◆	◆	◆	◆	◆
Ireland	**25% overall up to 86% in rural areas**						

Key to groundwater criteria

1 Groundwater-specific criteria have been set
2 Drinking water standards and guidelines are applied to groundwater
3 Criteria set for the protection of aquatic life are applied to groundwater
4 Criteria set for livestock watering and crop irrigation are applied to groundwater
5 Other criteria are used

The Netherlands has developed Intervention and Target Values for soil and groundwater as part of an assessment package which covers data acquisition, interpretation and remedial action decision-making, focused on restoring contaminated media to functional or multifunctional use. The soil criteria were set using a risk assessment model, which considered (i) risks to human health, via a number of exposure pathways, and (ii) the risks to soil fauna and flora. The groundwater criteria were derived from the soil criteria using partitioning relationships.

The international review has indicated that groundwater is widely used to supply drinking water, as shown in Table 1. Drinking water standards in European countries are based on the EU Drinking Water Directive and the technical basis for the derivation of these criteria, in common with those used in countries such as Canada, New Zealand and the USA, is largely the same. Drinking water standards are generally set on the assumption that individuals consume a defined volume of water (usually 2 litres per day). Other inputs include effects (toxicity) data and, in finalising criteria, issues such as odour and tainting are also considered.

Contamination assessment, in general, is undertaken within a risk assessment framework. A number of countries allow or provide for the use of risk assessment criteria to protect the receptors that could actually become exposed to the contamination. It is noted that this approach is consistent with the objectives of the proposed Water Framework Directive. To this end, numeric criteria such as those set to protect aquatic life and crops (via irrigation) and livestock are used in many of the countries surveyed. Where contaminants are detected at concentrations in excess of the appropriate criteria, site-specific risk assessment can be used to determine actual exposure levels and the degree of exposure – and hence risk – that may exist and, subsequently, the need to take action and the appropriate end-points.

GROUNDWATER GUIDELINE AND INTERVENTION VALUES FOR IRELAND

In developing a groundwater quality assessment methodology for Ireland the following aspects are considered relevant:

- Groundwater quality in Ireland;
- Pressures on groundwater;
- European legislation;
- Irish legislation;
- International policy and practice in the field of groundwater protection; and
- Priority contaminants.

These aspects will be integrated into a methodology, which will include proposed guideline and intervention values specific to Ireland and a model for applying these values. The outputs from the project are presently being examined and a draft methodology will be available from the EPA later in the year.

Proposed Model

A suggested model to characterise groundwater quality is outlined in Figure1. As an initial step a core group and site specific parameters (in some cases) are used to characterise groundwater quality. The core group consist of 17 parameters and can be divided into three generic groupings, namely inorganic parameters, physico-microbiological parameters, and organic parameters.

The suggested CORE GROUP at present consist of:

Ammonia; Chloride; Iron; Manganese; Nitrate; Phosphates; Potassium; Electrical Conductivity; pH; Coliforms (total); Coliforms (faecal) ; Total Hydrocarbons by GC [1] Benzene ; Ethylbenzene ; Toluene ; Xylenes; MTBE

Site-specific parameters may be identified locally using available data, (e.g. site history information, existing monitoring results, and anecdotal observations). A priority list of parameters and associated Guideline Values (GV), which will include List 1 substances will be developed as part of the methodology.

Groundwater quality assessment may proceed under the methodology described below on the basis that results of the analysis are compared with appropriate GVs and the need for any further action determined as follows :

---

[1] TPH by Gas Chromatography: This analysis can serve as a 'catch-all' and will present results for the general term 'Gasoline Range Organics' and the separate 'BTEX' parameters including MTBE.

- All parameter concentrations below the appropriate GVs – ongoing monitoring of groundwater quality may be appropriate, subject to the nature of the contamination source. Direct remedial action is not likely to be required.

- One or more parameter concentrations are above the appropriate GVs – further assessment is required and should include sampling, analysis and site-specific risk assessment, as appropriate. Direct remedial action may be required and the scope of such action will be determined upon conclusion of the further assessment. Remedial action could, depending on the circumstances, involve anything from changes in land use at the surface to an extensive groundwater cleanup exercise.

The EPA intends to consult widely in relation to the finalisation of its proposals and has made preliminary contact with a number of organisations in relation to the consultation process it intends to engage in.

ACKNOWLEDGEMENTS

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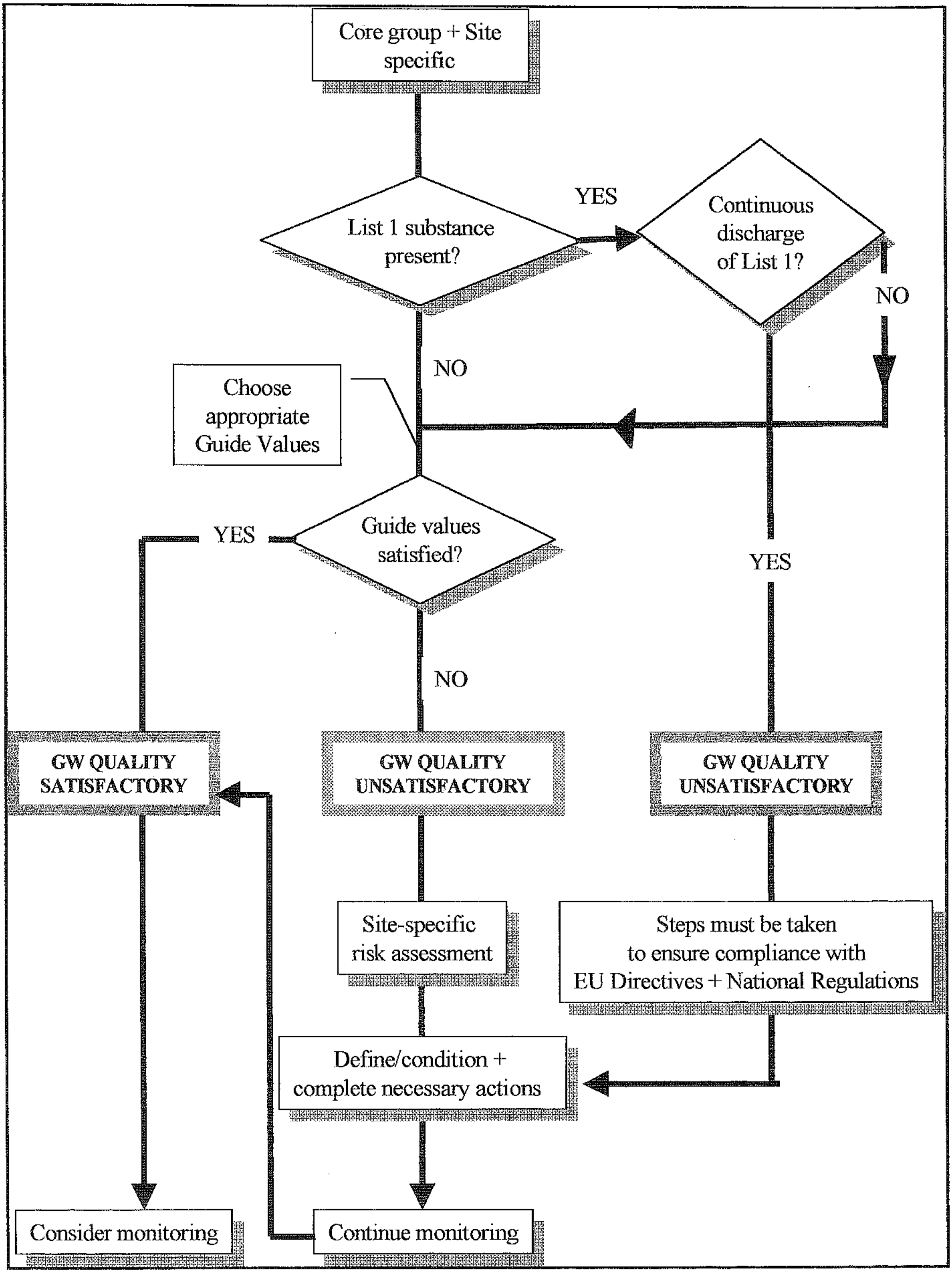
Figure 1 Proposed Model



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