Irish Group

# International Association of Hydrogeologists

11th Annual Groundwater Seminar
Killeshin Hotel, Portlaoise 9th and 10th April, 1991

## GROUNDWATER ASPECTS OF ENVIRONMENTAL IMPACT ASSESSMENTS

| Tuesday 9th April | | Speaker and Organisation |
|---|---|---|
| 10.15 | Registration and Coffee | |
| 11.00 | Welcome and Introduction | Bob Aldwell (President IAH Irish Group) |
| 11.15 | Current EIA Legislation in Ireland | Pat Timpson, Director Water and Waste Institute |
| 11.45 | EIA's and Groundwater | Dr. Catherine Coxon, Env. Sciences Unit, TCD. |
| 12.15 | Discussion | |
| 12.45 | **Lunch** | |
| 14.15 | Agriculture, Groundwater and EIA | Dr. Richard Thorn, Dept. of Env. Sci., Sligo RTC. |
| 14.35 | Industry, Groundwater and EIA | Kevin Cullen, Hydrogeological Consultant. |
| 14.55 | Waste Disposal, Groundwater and EIA | Shane O'Neill, ERA/Maptech Ltd. |
| 15.15 | Mining, Quarrying, Groundwater and EIA | Eugene Daly, GSI |
| 15.35 | Discussion | |
| 16.00 | **Coffee** | |
| 16.30 | EIA's and Groundwater - The US Experience | Dr. Ron Hoffer, Office of Groundwater Protection, US Environmental Protection Agency. |
| 17.30 | Discussion | |

| Wednesday 10th April | | |
|---|---|---|
| 9.15 | Wellhead Protection in the US | Dr. Ron Hoffer, Office of Groundwater Protection, US Environmental Protection Agency. |
| 10.00 | Aquifer Protection in Europe | Bob Aldwell, GSI |
| 10.30 | Discussion | |
| 10.45 | **Coffee** | |
| 11.15 | Groundwater Protection in Ireland | Donal Daly, GSI. |
| 11.45 | Aquifer Protection in Co. Wexford | Gerry Forde, Wexford Co. Co. |
| 12.35 | Discussion | |
| 13.00 | Lunch | |

# CURRENT EIA LEGISLATION IN IRELAND

**J.P. Timpson, National Water & Waste Institute**

## 1.0 INTRODUCTION:

Although the term Environmental Impact Assessment was not used until the passage of the National Environmental Policy Act (NEPA) in 1970 in the United States, forms of EIA had been undertaken earlier. For example, in the late 1930's, the Bureau of Reclamation carried out a study of the environmental and social effects of the Grand Coulee Dam on the Columbia River in the State of Washington (Clark 1990). Section 102 (2) of NEPA required all federal agencies to prepare an Environmental Impact Statement before making a recommendation on development proposals. More than 10,000 Environmental Impact Statements have been processed under NEPA.

In 1973, Canada followed the United States in initiating an EIA process and most developed countries now have this mechanism associated with their development legislation.

In Ireland there was a provision in Section 39 of the Local Government (Planning and Development) Act 1976 and Article 28 of the Local Government (Planning and Development) Regulation 1977, for the preparation by the developer "of a written study of what, if any, effect the proposed development would have on the environment relevant to the place where the development is to take place". However, this legislation was somewhat limited in that it did not apply to exempted development such as construction of a motorway by a Local Authority and it only applied to developments, the cost of which, was to exceed £5 million.

## 2.0 DEFINITIONS OF ENVIRONMENTAL IMPACT ASSESSMENT:

There is no general and universally accepted definition of EIA. There is however a great diversity of definitions which provides a broad indication of the objectives of the EIA but illustrating different concepts.

The object of an EIA is easier to define, for example, as a process to determine the potential environmental, social and health effects of a proposed development. It is important to appreciate that an EIA is not an environmental protection measure but a formal process between the, the public and the Local Authorities regarding the potential impact on the environment of any proposed new development.

## 3.0 EIA AND THE E.C. DIRECTIVE 85/337/EC

Environmental Impact Assessment was introduced to the European Community by Council Directive 85/337 "on the assessment of the effects of certain public and private projects on the environments". It was introduced in 1985, but because it was felt that development authorization procedures in many States were likely to require extensive modifications, three years were given for Member States to bring it into force, i.e. by July 1988.

The Directive sets out under what conditions the environmental assessment of a project is required, the minimum information it should contain and the consultations which need to accompany the process. When an assessment is required, it's results have to be taken into account in the granting Authority's decision on the project.

The Directive contains two lists of projects in Annex I and II. Those in Annex I require an Environmental Impact Assessment in <u>all</u> cases. A summary of the classes of projects in Annex I, is as follows

1. Crude oil refineries.
2. Thermal stations/installations/nuclear power stations/nuclear reactors.
3. Installations designed for permanent storage of radio-active waste.
4. Installations for melting of cast-iron and steel.
5. Installations for extraction and processing of asbestos and products.

6. Integrated chemical installations.
7. Construction of motorways/express roads/railways/airstrips.
8 Trading ports.
9. Waste disposal installations (incineration/chemical reatment/landfill of toxic and dangerous wastes.

The projects listed in Annex II, may require an Environmental Impact Assessment, where Member States consider that their characteristcs so desire. Member States may establish the criteria and/or thresholds necessary to determine which Annex II projects are to be subject to an assessment. This relatively straightforward-sounding procedure is complicated by a number of factors which reflect the diversity of administrative practice and different legal interpretations to the Directive in the Member States. In Britain, the Department of the Environment have stated that projects likely to have a significant effect must be subject to assessment, and then explains when a significant effect is likely, e.g. over 50ha for open cast mining!. (Woodford 1990).

The projects which may be subject an an EIA in Annex II are presented below.

1. Agriculture.
2. Extractive Industry.
3. Energy Industry.
4. Processing of metals.
5. Manufacture of glass.
6. Chemical Industry.
7. Food Industry.
8. Textile, leather, wood and paper industries.
9. Rubber Industry.
10. Infrastructure projects.
11. Modifications to projects included in Annex I.

The Council Directive stresses that the best environmental policy is in preventing the creation of pollution at source rather than subsequently trying to counteract its effects. It requires that development of public and private projects, which are likely to have a significant effect on the environment, should be granted only after a prior assessment of the likely significant environmental affects of these projects has been carried out. This assessment "must be conducted on the basis of the appropriate information supplied by the developer, which may be supplemented by the Authorities and by the people who may be concerned by the project in question".

Article 1 of the Directive is concerned with definitions and it describes the competent authority or authorities as those which the Member States designate as responsible for performing the duties arising from the Directive. In Ireland, the competent authority would appear to be the Local Authorities, but it is obvious from the statements of the Minister for Energy and the Minister for Environmental Protection, that the proposed Environmental Protection Agency will have a role as a competent authority, at least for major development proposals. (Timpson, 1990).

Article 3 requires that the EIA will identify, describe and assess the direct and indirect effects of each specific project on the following factors:-

- Human beings, fauna and flora,
- Soil, water, air, climate and landscape,
- The interaction between the factors mentioned in the first and second indents,
- Material assets and cultural heritage.

Article 4 identifies the projects listed under Annex I and Annex II. It also indicates that Member States may establish the criteria and/or thresholds necessary to determine which of the projects listed in Annex II are subject to an assessment.

Article 5 indicates the appropriate form of information required of the developer in the EIA. This must include at least :-

- A description of the project, comprising information on the site, design and size of the project,
- A description of the measures envisaged in order to avoid, reduce and if possible remedy significant adverse affects.
- The data required to identify and assess the main effects which the project is likely to have on the environment.,
- A non-technical summary of the information mentioned above.

Article 5 requires that Member States ensure that any Authority, with relevant information in its possession, make this information available to the developer.

Article 6 requires that the Member States ensure that all State Bodies with specific environmental responsibility are given an opportunity to express their opinion on the request for development consent. This Article also requires that Member States make the request for development and EIS available to the public and that the public are given the opportunity to express an opinion before the project is initiated.

Article 13 states clearly that Member States have the right to lay down stricter rules, if they so wish, regarding the scope and procedure for assessing environmental effects.

## 4.0 IRISH REGULATIONS FOR DIRECTIVE 85/337/EEC

Directive 85/337 on EIA was brought into operation with effect from 3rd July 1988 in accordance with administrative instructions issued by the Department of the Environment. It was subsequently transposed into Irish Law by way of Regulations made by the Minister for the Environment. Three Statutory Instruments, issued to date, giving legal effect to the Directive are listed below:-

The European Communities (Environmental Impact Assessment) Morotways) Regulations, 1988 (S.I. No. 221 of 1988).

The European Communities (Environmental Impact Assessment) Regulations, 1989 (S.I. No. 349 of 1989).

Local Government (Planning & Development) Regulations, 1990 (S.I. No. 25 of 1990).

### 4.1 European Communities (Environmental Impact Assessment) (Motorways) Regulations 1988 (S.I. No. 221 of 1988).

These Regulations require that a road authority, before making a motrorway scheme, must prepare a study of the likely effects on the environment of the proposed motorway. This environmental impact study, which must contain specific information, has to be submitted to the Minister for the Environment, when the road authority seeks his approval for the motorways scheme. The Environmental Impact Study must be available to the public and must be sent to specified bodies such as Bord Failte and An Taisce.

## 4.2 European Communities (Environmental Impact Assessment) Regulations , 1989 (S.I. No. 349 of 1989

These Regulations modified existing Acts to incorporate EIA procedures. The Acts modified include the following :-

Local Government (Planning & Development) Acts 1963 to 1983),
Public Health (Ireland) Act 1878,
Water Supplies Act, 1942,
Arterial Drainage Act, 1945,
Fisheries (Consolidation) Act, 1959,
Petroleum & Other Minerals Development Act, 1960,
Gas Act, 1976,
Fisheries Act, 1980,
Urban Renewal Act, 1986.

The Local Government (Planning & Development) Acts were modified to provide for the incorporation of EIA into the planning control process. It also established an EIA procedure for relevant development by State Authorities.

Part III of the 1989 Regulations deals with development consent procedures for a range of Acts including approval of arterial drainage schemes under the Arterial Drainage Act 1945 and the granting by the Minister for the Marine of fish culture licences under the Fisheries Acts 1959 and 1980.

The Regulations list the procedure which must be followed in the case of relevant developments such as:-

(a) Preparation of an EIS,
(b) Giving notice of preparation of the EIS to public and precribed bodies.
(c) Availability for consultation and purchase of copies of the EIS,
(d) Making of submissions on the environmental impact of the proposal by interested persons and bodies.
(e) The giving of notice by the Authority of its decision on the proposal.

## 4.3 Local Government (Planning & Development) Regulations (S.I. No. 25 of 1990)

This Regulation establishes the procedure through which relevant developments undertaken by or on behalf of Local Authorities will be subject to EIA. A Local Authority may not undertake any development for which an EIS must be prepared, unless the Minister for the Environment certifies that the proposed development, would, in his opinion, not have significant adverse effects on the environment, or that it would embody the best practicable means to prevent or limit such effects.

## 5.0 IMPLEMENTATION

Since 1988, a range of Environmental Impact Statements have been submitted to Local Authorities covering road developments, housing, hydro-electric development, establishment of chemical industry, etc. Earlier this year a major five volume EIS was prepared and submitted by EOLAS for a proposed mine at Galmoy in Co. Kilkenny by Conroy Mining Limited.

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EAH 9/4

LECTURE 1:
Main Stages in the EIA Process

1. Screening
2. Scoping
3. EIA Preparation
4. Review
5. Monitoring
6. Auditing

Advice: A successfull EIA should:
1. Seasonal look at Baseline situation
2. Co-operation between authorities
3. Independent review
4. Public comment should be allowed
5. Monitoring over time.

Brian Archer — Publication

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# ENVIRONMENTAL IMPACT ASSESSMENTS AND GROUNDWATER

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Paper presented to International Association of Hydrogeologists (Irish Group) 11th Annual Seminar on "Groundwater aspects of environmental impact assessment", Portlaoise, 9th & 10th April 1991

## Introduction

Groundwater is a hidden and sometimes forgotten resource, yet it accounts for about 25% of Irish water supplies, and some parts of the country are very heavily reliant on it. It is unlikely to be ignored if the environmental impact of a development extending below ground such as a quarry or mine is being contemplated. However, a wide range of surface activities and developments can also have implications for groundwater, and it is important to ensure that this fact is not neglected when scoping or drawing up a workplan for an environmental impact assessment (EIA).

The water in aquifers is not an isolated, static resource, but forms part of the hydrologic cycle. Some parts of the aquifer may be confined by impermeable rocks or clay, but elsewhere rainwater can enter and *recharge* the aquifer by percolating down through the soil and subsoil to the saturated zone. Any materials stored, spread, spilled or leaked onto the ground surface may therefore be leached downwards to groundwater, depending on the nature of the materials and the geological situation. In some instances, the surface drainage system may also feed the aquifer, with water seeping downwards from river beds - this input is particularly significant in the case of karst limestone areas with swallow holes and sinking streams. The natural *discharge* or output from aquifers is mainly by seepage into river beds, providing the baseflow that keeps rivers flowing all year round, more rarely by point discharge at a spring or rising. In addition, of course, groundwater can be removed artificially by pumping at boreholes. Anything that interferes with these inputs and outputs, by altering their quantity or quality can thus have an impact on aquifers.

This paper considers the groundwater implications of a wide range of developments requiring an environmental impact statement (EIS). The guidelines on EIS production and evaluation provided by the legislation are considered with regard to groundwater, and the kind of hydrogeological investigations which might be undertaken as part of an EIA are discussed.

## Groundwater implications of some developments specified in the Irish EIA legislation

The developments for which an EIS is required under the Irish legislation implementing Directive 85/337/EEC are listed in the First Schedule, or Article 24, of S.I. 349 (1989). This is reproduced in Appendix 1 of these proceedings. Some examples of activities requiring an EIS and their possible impact on groundwater are discussed below, and the item number in the first schedule is given so that the reader can refer to it for the exact wording. While this covers a wide range of developments, it is not intended to be comprehensive, and omission of an activity from the list should not be assumed to imply that it has no implications for groundwater. The activities are grouped according to the type of potential threat to groundwater.

1. **Potential impact on groundwater quantity**

Large-scale water abstraction can have an impact on groundwater resources, with the possibility of water tables being lowered. An EIS is required for all geothermal drilling, and for drilling for water supplies of more than 5000 cubic metres per day (Part II, 2(b)). (Taking a rate of 200l/day/person, as used in the Regulations on Water for Human Consumption, this corresponds to a population of 25,000).

Water management projects for agriculture (Part II, 1(b)) may also have groundwater implications - irrigation may raise water tables while drainage may lower them. The effect of arterial drainage schemes on groundwater can be quite significant, and these now require an EIS for catchment areas greater than 5000 ha (Part II, 10(e)).

Artificial impoundments of surface water or changes to river flow (Part II, 3(j) & 10(f)) may also have an impact on groundwater resources if there is a hydraulic connection between the aquifer and the surface drainage system.

Dewatering associated with mining and quarrying (Part II, 2(c) & (d)) involves a drop in the groundwater table which may have implications for groundwater supplies or spring flows.

A fall in the water table may not only have an impact on groundwater supplies (particularly shallow wells) but it may also have wider environmental implications. For example, a decrease in river baseflow would provide less dilution of contaminants when flow is at a minimum in late summer, and a decrease in flow from seepages and springs feeding wetlands such as fens and turloughs could have serious a ecological impact.

2. **Land-use changes with groundwater quality implications**

Land reclamation and change to more intensive land-use (Part II, 1(a) & 1(c)(ii)), particularly a change from woodland or unimproved grassland to tillage, could have implications for groundwater quality, notably increased nitrate levels from leaching of fertilizers or natural soil nitrogen released on ploughing, or leaching of pesticides to groundwater.

Afforestation with coniferous trees (Part II, 1(c)(i)) could result in increased acidification of soil and groundwater and possible problem levels of aluminium, although this would only be a potential problem in areas of acid rocks such as quartz sandstones. (Similar problems could also arise due to acid deposition associated with air pollution from power plants (Part I, 2 and Part II, 3(a)) or industrial installations).

3. **Disposal of wastes at the surface or underground, with the possibility of leaching of contaminants to groundwater**

Disposal of solid wastes on or below the ground can result in groundwater contamination if rainwater passing through the waste is allowed to percolate down to the water table.

Installations for the storage or disposal of radioactive waste and hazardous waste disposal installations including landfills require an EIS (Part I, 3 & 9). However, ordinary domestic refuse can also generate a noxious leachate which may pollute groundwater if not properly managed, and installations for the disposal of industrial and domestic waste with an annual intake greater than 25,000 tonnes are also included (Part II, 11(c)). Sludge deposition sites where the expected annual deposition is 5000 tonnes of wet sludge (Part II, 11(e)) also require an EIS, which would need to evaluate the risk of groundwater contamination.

Animal rearing or housing units involve the storage and disposal of manures or slurries. The legislation covers both poultry and pig rearing installations (Part II, 1(d) & (e)), and an EIS of such an enterprise would have to consider how these wastes are to be managed and disposed of in order to avoid contamination of groundwater as well as surface water. Holiday developments (as listed in Part II, 11(a)) which are not on mains sewerage might involve small-scale wastewater treatment plants with disposal of effluent to the soil or subsoil, and the groundwater quality implications of such disposal methods would need evaluation.

Wastes associated with the mining industry (Part II, 2(c)) disposed of in spoil heaps or tailings ponds may result in leaching of heavy metals to groundwater.

4. **Handling and storage of industrial wastes and potential pollutants, with the possibility of accidental spillages or leakages**

   The food industry (Part II, 7) generates effluents with high B.O.D. and nutrient content, which could pollute groundwater if improperly managed. Slaughter houses pose a particular threat, and these require an EIS where the daily capacity exceeds 1500 sheep, 750 pigs or 300 cattle (Part II, 7(f)). Wastewater treatment plants (Part II, 11(d)) also pose a potential risk of groundwater contamination from effluent leakages from pipes, tanks or lagoons.

   Groundwater contamination due to the leakage or spillage of petroleum products must also be considered in drawing up EISs for extraction (Part II, 2(e),(f),(g)), oil refining (Part I, 1), surface and underground storage (Part II, 3(c),(d),(e)) or pipelines (Part II, 10(h)).

   The possibility of chemical leakages or spillages ( of solvents, heavy metals etc.) must be considered for a wide range of industrial developments including chemical installations (Part I, 6 and Part II, 6) and processing of metals (Part II, 4). The textile, leather, wood and paper industries (Part II, 8) may involve the use of dangerous synthetic organic chemicals for degreasing, dyeing and bleaching.

It can be seen that many more of the activities in the First Schedule have implications for groundwater than might at first be supposed.

<u>Guidance provided by the legislation on groundwater components of an EIS</u>

Unless it is self-evident that a proposed development has no implications for groundwater, it will be necessary for the developer or the environmental consultant compiling the EIS to seek hydrogeological advice. With some developments, all that may be required is a single paragraph explaining why no impact on groundwater is anticipated, while with others (for example waste disposal sites), the hydrogeological study will be a major integral component of the EIS. Equally, the people evaluating the EIS will require hydrogeological expertise to judge the validity of the groundwater component. What guidelines does the legislation provide on what information should be provided and how it should be evaluated?

The information to be provided in an EIS is outlined in the Second Schedule (Article 25) of SI 349 (1989). This is reproduced in Appendix 2 of these proceedings. It basically lists the requirements of the E.C. Directive without expanding further. The "specified information" which <u>must</u> be included (corresponding to Article 5.2 of the Directive) is very broad and non-specific, while the "further information" which <u>may</u> be included (corresponding to the other items listed in Annex III of the Directive) gives slightly more detail, but still leaves much room for interpretation of the scale of investigation required. The notes for the guidance of local authorities on implementation of the Directive produced in February 1990 do not expand any further on this important aspect of the legislation, and although the Environmental Protection Agency Bill, 1990, includes provision for the Agency to draw up guidelines on the information to be contained in an EIS, this possibility is some way in the future. Items of specified or further information from the Second Schedule which could relate to groundwater include: characteristics of the production processes, including the nature and quantity of the materials to be used; the estimated type and quantity of expected residues and emissions (including pollutants of surface water and groundwater); the likely significant effects on the environment, with reference to water, soil, human beings, and the interaction between these; measures envisaged to avoid, reduce or remedy adverse effects; the main alternatives studied, taking into account the environmental effects; the forecasting methods used to assess any effects on the environment; difficulties such as technical deficiencies or lack of knowledge encountered in compiling information. The kind of investigations which might be undertaken under these headings are discussed in the next section.

It is important that the EIS should deal adequately with all of these aspects: it is not possible to justify the omission of information which may be relevant on the grounds that it is not included in the specified information. Firstly, this is so broad that it can be interpreted to include almost anything of relevance, and secondly, the body evaluating the EIS (whether a local authority, An Bord Pleanala or the Minister for the Environment) has the right to request any additional information which it deems relevant.

With regard to the evaluation of an EIS, the chief indication of where the necessary expertise is to be obtained comes from the details in SI 25 (1990) of the bodies to which a notice or a copy of the EIS must be sent. There is a clear recognition here that the evaluating body may not have the necessary expertise and should therefore consult with the appropriate public body. For example, if a proposed development is likely to have a significant effect on wildlife, the EIS must be sent to the Commissioners of Public Works, which includes the Wildlife Service). The obvious public body with groundwater expertise is the Geological Survey of Ireland, yet there is no mention of referral of projects with groundwater implications to this body, apart from a requirement for any EIS dealing with the extraction of minerals under the Minerals Development Acts (i.e. minerals other than stone, gravel, sand or clay) to be sent to the Minister for Energy (who includes the Geological Survey within his brief). If there is a possibility of appreciable discharges of polluting matters to waters, the EIS must be sent to the appropriate Regional Fisheries Board, so this suggests an awareness of surface water pollution only, despite the mention of groundwater pollution in the list of further information. There is provision for referral to the appropriate health board where matters of public health, which could include groundwater pollution, are concerned, but the health boards would not all have the necessary expertise to evaluate groundwater pollution risks.

This does not mean that hydrogeologists are excluded from the decision-making process, however. For all developments covered by the EIA regulations, whether private, local authority or State, public notice in newspapers must be given and copies of the EIS must be available for consultation and for sale at a reasonable cost. The decision taken on the proposed development must take into account any submissions or observations from any person or body. Thus, although there is no formal, guaranteed involvement for hydrogeologists, they are free to make submissions on any EIS either as individuals or as a group (such as the IAH Irish Group).

## Investigations which might be undertaken as part of an EIA, to evaluate impact on groundwater

The first step which might be undertaken (under specified information a & b and further information b & c of the Second Schedule of SI 349 (1989)) is to carry out an inventory of all materials, products, wastes etc. associated with the development. This would include detailed reference to how these materials are to be handled, stored and disposed of, and what opportunities there are for deliberate or accidental contact with water or the ground surface.

Secondly, if there is any possibility of anything other than inert materials coming into contact with the soil, or with water which might reach aquifers by percolation through the soil (or via swallow holes in the case of karst areas), the study must then consider the possible effects on groundwater (under specified information c and further information e). Given that accurate prediction of groundwater impact is difficult, this work should include a discussion of the forecasting methods used to assess the effects on groundwater (under further information f), and any difficulties encountered, such as technical deficiencies or lack of knowledge (under further information g). The information required to predict the impact on groundwater will obviously vary from one EIS to another, but it is likely to include the following:

If material might be deposited or spilled on the ground surface, the soil type will be the first consideration - how permeable is it, and what is its capacity to attenuate pollutants? In the case of both surface and subsurface storage, discharge or leakage, an understanding of the underlying geology is crucial. Are there unconsolidated deposits over the bedrock? If these are thick and permeable (e.g. outwash sands and gravels), they may constitute an aquifer themselves, while if they are of lower permeability (e.g. glacial till or boulder clay) they may be very important in preventing the entry of contaminants to a bedrock aquifer underneath. Is the bedrock impermeable or does it constitute an aquifer? If so, is it fissured or karstified? How thick is the unsaturated zone (which has slower flow rates and more attenuation of contaminants)? What are the aquifer characteristics (e.g. permeability), and what is the present water quality?

It should be noted that there is an inverse relationship between the risk of surface water pollution and the risk of groundwater pollution. Gley soils on heavy boulder clay will generate surface runoff, and this is recognised in the requirement for an EIS for pig rearing installations holding more than 1000 units on gley soils, compared with more than 3000 units on other soil types. However, groundwater pollution can occur if there are thin soils directly over fissured bedrock, or over very permeable glacial deposits. The discretion allowed in the legislation to require an EIS for developments below the size threshold in environmentally sensitive areas might reasonably be applied in such situations. For example, an abbatoir for 300 cattle per day automatically requires and EIS, but in a karst limestone area with thin or absent glacial drift one might be justified in requesting an EIS for one with a lower capacity.

In addition to evaluating the geological factors, it will be necessary to determine the properties of any potential groundwater contaminants associated with the development. Are they soluble, chemically reactive, biodegradable, retained by adsorption or ion exchange etc.? The properties will vary depending on the hydrogeological conditions (e.g. pH and redox potential) so these conditions and any possible future changes in them must be taken into account. Also, there may be interaction between different materials or wastes, e.g. organic wastes may mobilise heavy metals by the formation of soluble organo-metal complexes.

The detail of the investigation required will vary depending on the nature of the enterprise and the hydrogeological situation. A desk study involving consultation of maps, published literature and unpublished reports will provide a valuable starting point, particularly if a groundwater protection plan is available for the area concerned. However, where the proposed development site is underlain by an aquifer and there is a real possibility of an impact on that aquifer, specific site investigations will need to be undertaken. These might include resistivity surveys to determine geological variations; test drilling and logging of geological materials; test-pumping and other field and laboratory methods of determining hydrogeological properties such as permeability; water level measurements in monitoring boreholes to determine thickness of the unsaturated zone and direction of groundwater flow; water tracing experiments to determine flow directions and velocities in fissured and particularly in karstified aquifers; a programme of water quality sampling both upgradient and downgradient of the proposed development to provide baseline data. The forecasting methods in more detailed and sophisticated studies might include computer modelling of groundwater flow and contaminant dispersal. However, it should be recognised that the field data are of fundamental importance, and modelling should only be undertaken where the input variables are determined from real field data and not from assumptions. As mentioned above, the prediction methods used and their limitations should be made clear.

The groundwater component of the EIS should also discuss the measures envisaged to avoid, reduce or remedy any adverse impact on groundwater (under specified information d). In the case of storage of wastes, this might include the use of impermeable containers or liners which are not susceptible to corrosion or breakdown when in contact with the waste. The next line of defence might be a leak detection system (e.g. between an inner and an outer liner of a landfill or chemical storage tank). The detection of any changes in groundwater quality by a regular monitoring programme for a nework of observation boreholes might also be appropriate. An emergency plan might be drawn up, for use in the event of a leakage or spillage, involving for example the pumping of groundwater from boreholes immediately adjacent to the site to prevent widespread dispersal of contaminants in the aquifer.

The EIS may also include an outline of the main alternatives studied, and the reasons for the choice made, taking into account the environmental effects (under further information d). Where impact on groundwater is an important aspect of the development (e.g. for a waste disposal site), the alternatives should be examined with regard to groundwater vulnerability at an early stage of the investigation. If this has been done, it should be in the developer's interest to include this information in the EIS, as it might serve to demonstrate that alternative locations would have a greater risk of groundwater pollution than the site selected.

It is not possible to give details here of all data relevant to an EIS with a groundwater component - the purpose of this paper is rather to highlight some of the issues involved, in the hope that it may serve to increase the awareness of groundwater resources in the context of environmental impact assessment.


85/337/EEC: Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment. (Generally referred to as the "Environmental Impact Assessment Directive").

SI 349 (1989): European Communities (Environmental Impact Assessment) Regulations, 1989. Statutory Instrument No. 349 of 1989, Stationery Office, Dublin.

SI 25 (1990): Local Government (Planning and Development) Regulations, 1990. Statutory Instrument No. 25 of 1990, Stationery Office, Dublin.

# AGRICULTURE, GROUNDWATER AND EIA; 'SCREENING' AND 'SCOPING' THE GROUNDWATER COMPONENT OF AN ENVIRONMENTAL IMPACT ASSESSMENT

**Richard Thorn, Department of Environmental Science, Regional Technical College, Sligo.**

Paper presented to 11th Annual International Association of Hydrogeologists (Irish Group) Seminar on 'Groundwater Aspects of Environmental Impact Assessments', Portlaoise, 9th and 10th April, 1991.

## Introduction

The aim of this paper is to (i) 'screen' those developments of an agricultural and related nature that require the submission of an Environmental Impact Statement (EIS) with the Planning Application and to (ii) 'scope' the likely contents of the associated environmental impact assessment (EIA).

It is not the intention of the paper to provide the technical information necessary to carry out the impact assessment, although a **Bibliography** is provided that may help the consultant in undertaking the EIA and assist the planning authority in assessing the EIS.

It should be noted that if the EIA for a proposed development envisages that there will be an impact on groundwater then the onus is on the developer to state in the EIS how the impact will be dealt with.

## Screening the Development

Screening is the determination of the need for an EIA. Whether an EIA is needed for a particular development depends on the scale of the development proposed and the likely degree of public opposition to the project. A number of methods are used to assist in deciding which developments require an EIS and these include, initial environmental evaluations, project criteria (thresholds) and the use of positive lists.

The European Community Directive of 1985 (impact assessment directive - enacted in Ireland through Statutory Instruments Nos. 221 of 1988 and 349 of 1989) is an example of a positive list that incorporates project criteria. This means that the Directive and the Statutory Instruments not only identify types of developments that require an EIA but also specify, for certain types of developments, the threshold criteria (e.g. size of development, amount of waste to be produced/disposed of, etc.) that govern the carrying out of EIA's for such projects. Schedule 1 of SI No. 349 of 1989 lists those developments (other than motorways which are the subject of SI No. 221 of 1988) for which an EIS is mandatory in the Republic of Ireland. (Schedule 1 of SI No. 349 of 1989 is copied in full in Appendix 1 of these conference proceedings). 15th Feb 1990

It is important to note that it is not only those projects listed in Schedule 1 of SI. No. 349 of 1989 that require an EIS to be submitted with the planning application; under the Local Government (Planning and Development) Regulations of 1990 (SI No. 25 of 1990) the planning authority may require an EIS for developments that fall below the project thresholds. For example, if it is proposed to develop a piggery unit of less than 3,000 spaces, the waste from which will be spread on a thin, free draining soil overlying a fissured aquifer, the planning authority has it within its power to insist on the provision of an EIS if it feels that there is a danger to groundwater.

Table 1 lists those agricultural and related developments that may have an impact on groundwater and that require an EIS to be submitted with the planning application. The classes of developments given in the Table are as presented in

Schedule 1 of SI No. 349 of 1989, in which a more complete description of the projects may also be found.

Table 1
Agricultural and Related Developments that may have an Impact on Groundwater and that Require an EIS to be Submitted with the Planning Application

| Class of Development | | Development |
|---|---|---|
| Agriculture | (a) | The use of uncultivated land or semi-natural areas for intensive agricultural purposes. |
| | (b) | Water management projects for agriculture. |
| | (c) | Afforestation and land reclamation where the area involved would be greater than 200 hectares |
| | (d) | Poultry rearing installations. |
| | (e) | Pig rearing installations. |
| Food Industry | | All food industry projects noted in Schedule One of SI No. 349 of 1989 in which it is proposed to land spread waste materials, e.g. whey, blood, fish waste etc. |
| Other Projects | | Sludge deposition sites where the expected annual deposition is 5,000 tonnes of sludge. |

**Scoping the Development**
Scoping may be defined as a procedure for establishing the terms of reference of an EIA. The objectives of scoping are:

(1) To identify the concerns and issues which warrant attention.
(2) To provide an opportunity for public involvement.
(3) To provide a detailed brief for the investigation of specific issues associated with the scheme.
(4) To facilitate the efficient preparation of an environmental report.
(5) To save time.

(After Davies, 1990)

This paper is concerned primarily with objectives 1 and 3 above.
On the basis of the potential impact on groundwater of the developments in Table 1 we can identify five groups of development - those which involve:

(i) Water management projects (e.g. abstraction for irrigation, drainage).
(ii) Afforestation, land reclamation, cultivation of virgin or near virgin land.
(iii) The spreading of organic wastes from piggery and poultry units.
(iv) The spreading of food processing wastes.
(v) The spreading of sewage sludge on agricultural land.

*(i) Water management projects*

Groundwater abstraction may be carried out to supply livestock drinking and cleaning requirements or on-farm vegetable washing. The impact of this type of development will be to lower water table levels in the vicinity of the pumping well which may affect borehole and spring supplies and may also affect the baseflow component of rivers and streams. However, unless it is a very large supply such a development is unlikely to have a significant impact in Ireland.

Groundwater abstraction for irrigation may, in addition to lowering water tables in the vicinity of the pumping borehole(s), raise water tables and increase the salinity of both soil and groundwater at the point of irrigation. The impact of groundwater abstractions for irrigation is unlikely to be significant in Ireland.

*(ii) Afforestation, land reclamation, cultivation of virgin or near virgin land.*

Afforestation with coniferous trees has the capacity to cause an increase in the acidity of soil and groundwater with consequent problems of enhanced levels of metals, in particular iron and aluminium, in both surface and groundwaters. The acidification will be greatest where the underlying rocks are acidic, e.g. granites, gneisses and some sandstones. To assess the likely impact of afforestation on groundwater the information required will include the folowing:

Size of development.
Rock and overburden type and characteristics.
Extent and characteristics of groundwater resources.

Land reclamation and the bringing into cultivation of virgin or near virgin land is likely to have implications for groundwater quality. These changes, particularly increases in the concentration of nitrogen compounds in groundwater, may occur through the application of fertilisers in excessive quantities or at inopportune times of the year. The changes may also relate to reductions in the organic matter content of the reclaimed soils. Such reductions, which are brought about by microbial processes, result in the release of nutrients, in particular nitrogen, which can move to groundwater. Rises in the nitrate concentration of groundwater have been ascribed to the bringing into cultivation of virgin or near virgin land. Applications of pesticides may also result in a deterioration in groundwater quality. To assess the likely impact of land reclamation projects on groundwater the information required will include the folowing:

Size of project.
Timetable for project.
Soil and overburden type and characteristics.
Cropping and fertilising regime.
Extent and quality of groundwater.

*(iii) The spreading of organic wastes from piggery and poultry units*

Wastes from pig and poultry production units contain large quantities of nutrients (N, P and K), organic matter and, in the case of pig wastes, copper. Both chemical and hydraulic overloading of soils can result from the landspreading of these materials. Hydraulic overloading is more likely to effect surface waters than groundwaters and is not dealt with further here. Application of quantities of wastes in excess of plant requirements can lead to a build up harmful salts and copper and will lead to leaching of excess nitrates to groundwater. The EIA for a pig or poultry unit should therefore pay especial attention to the design of the land spreading operation.

The spreading of animal wastes may also have a role in disease dispersal if diseased animals are contributing to the waste volume. The control of pathogens is best undertaken by a combination of waste storage, grazing restrictions and placement of the waste on tillage rather than pasture crops.

The following information will be necessary to assess the impact of land spreading of pig and poultry waste on groundwater:

Amount and type of waste.
Soil and overburden characteristics.
Design of proposed spreading operation.
Extent and quality of groundwater.

*(iv) The spreading of food processing wastes*

A range of wastes from the food processing industry are and have been spread on land and include paunch material, blood and whey. Because the wastes frequently contain large quantities of nutrients and organic matter problems of chemical overloading similar to those described in (iii) above may arise. In particular, blood contains very large quantities of nitrogen and this must be taken into account when considering the design of a land spreading operation. A further problem arises with some food processing wastes, notably waste dairy products; they may, because they are highly reducing, cause iron and manganese to be mobilised in the soil and move to groundwater

The information required to assess the impact of land spreading of these wastes will be the same as in (iii) above.

*(v) The spreading of sewage sludge on agricultural land*

The spreading of sewage sludge on agricultural land is controlled by a European Community directive of 1986. Sewage sludge is defined by the directive as 'residual sludge from sewage plants treating domestic or urban waste waters and from other sewage plants treating waste waters of a composition similar to domestic and urban waste waters'. As alternate disposal methods, e.g. sea dumping, become more expensive and/or illegal, land spreading of sewage sludge will become a favoured option. The directive lays down rules as to what type of soils and on to what crops the sludge can be spread.

The main groundwater problems associated with the spreading of sewage sludge are, elevated metal levels, particularly if the soil is acidic (<pH 6), and disease spread.

The following information will be required to assess the likely impact on groundwater of the land spreading of sewage sludge:

Amount and composition of sludge.
Soil and overburden characteristics.
Design of spreading operation.
Extent and character of groundwater resources.

In addition, the directive also requires that monitoring of sludge and soil be carried out on a regular basis.

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Various Authors in *Environmental Impact of Landspreading of Wastes*. Proceedings of Seminar in Johnstown Castle Centre for Soils and Environmental Research and Development, Wexford. 30-31 May, 1990. (Contains a number of very useful papers, in particular that by Carton which provides a code-of-practice for slurry management)

# THE EIA OF A LANDFILL WITH RESPECT TO WATER

## 1. INTRODUCTION

This paper examines S.I No. 349 of 1989 in terms its impact on water in the context of a landfill development. It examines the potential effects on both surface water and ground water. It sets out to determine which aspects of the statute are of particular relevance and how they have a bearing on landfills and water. This paper further sets out to interpret that statute in the context of landfill development and water and endeavours to highlight what should be expected in an EIA and EIS for a landfill development. The main emphasis is on the relevance of water with the context of an EIA and to ensure that all the pertinent aspects have been addressed.

The European Communities (Environmental Impact Assessment) Regulations, 1989 (S.I. No. 349 of 1989) has already been examined in the overall context of planning and developments as part of this series of presentations on EIA's and ground water. Certain activities under the headings of agriculture, extractive industry and landfill are being individually examined within the context of their impact on water.

It must be borne in mind when assessing any EIA and the accompanying Statement that the data, results and interpretation will be presented such that the favourable aspects will be enhanced and the less favourable or detrimental aspects will be subdued. Assessing an EIS is simply not a question of checking off a list of statuary requirements as given in the Article 25 of the EIA legislation to ensure that they have been examined. Rather it should be a critical examination to determine whether the EIA actually addressed the problems of a particular site and attempts to provide solutions to those problems. The planning authority must work hard at each application to cross check data, figures and interpretations.

## 2. EIA LEGISLATION

The EIA regulations are examined here for the development of a landfill operation.

The definition of an EIS is the starting point before examining the detail of how it effects the development of a landfill.

The definition of an *Environmental Impact Statement* in the legislation is given as :

> A statement prepared in accordance with a requirement of or under any enactment of the effects, if any, which proposed development, if carried out, would have on the environment.

An EIS is compulsory if installations for the disposal of industrial and domestic waste with an annual intake are greater than 25,000 tonnes. However there two other instances where an EIA could be compulsory. These are :

**Local Government (Planning and Development) Regulations, 1990, (S.I. No. 25 of 1990) : Article 6 (1)**

Where a planning authority receive a planning application in respect of any development which would be of a class referred to as being required to have an EIS carried out as part of its planning permission but for not exceeding a quantity, area or other limit for the time being specified in relation to that class, and where they consider that the development would be likely to have significant effects on the environment, they shall require the applicant to submit an EIS in respect of the development.

In layman's terms if the planning authority consider that a development, for example, of a landfill, will have an effect on the local environment then they can insist that an EIS is prepared as part of the planning application regardless of the size of the development.

**Local Government (Planning and Development) Regulations, 1990, (S.I. No. 25 of 1990) : Article 35**

Where development proposed to be carried out by or on behalf of a local authority would be of a class referred to in Article 32 but for not exceeding a quantity, area or other limit for the time being specified in relation to that class, the Minister may, where he considers that the said development would be likely to have significant effects on the environment, require the local authority to cause an environmental impact statement to be prepared in respect of that development.

Again in layman's terms if the Minister considers that a development, for example, of a landfill, by a local authority will have an effect on the local environment then he can insist that an EIS is prepared as part of the development regardless of the size of that development.

## 3. GROUND WATER IN THE ENVIRONMENT

Ground water and surface water are both part of the hydrological cycle. The hydrological cycle in relation to its effect on a landfill must be understood before the impact of a landfill on water can be fully appreciated.

The usual starting point taken for the hydrological cycle is precipitation. Precipitation on reaching the ground can either infiltrate into the soil or it can flow overland. If it flows overland it can either flow into the landfill increasing the volume of leachate that could be potentially generated or it can flow overland and out of the landfill carrying with it any waste liquids generated in the landfill.

Overland flow whether originating within the landfill or outside the landfill could finally end up in a surface water body. This could be either a stream, river or lake. The quality of that overland flow would be very much dependent on its flow path. Therefore overland flow paths into and out of a landfill site must be identified and recommendations given to minimise their effect on the landfill.

Infiltration is precipitation actually entering the soil. Similarly it can occur within the landfill or outside the landfill. The infiltration within the landfill could increase the volumes of leachate that could potentially percolate out of the bottom of the landfill. Infiltration occurring outside the landfill could percolate into the underlying water table and increase the dilution potential of the ground water.

## 3. POTENTIAL IMPACT OF LANDFILL ON WATER

Why be concerned about ground water or surface water at all? The reason is that a landfill development could impact upon several stages of the hydrological cycle. Geological material of any age, constituent or permeability will be saturated below a certain depth. The depth to the ground water will vary from area to area. The permeability of the saturated material will also vary from place to place. Ground water that is deep below the surface and in low permeability material will be least effected by a landfill development. Conversely ground water close to the surface in high permeability material could be severely effected by a landfill development. There is a complete gradation of variations between these two end points.

The infiltrating water, on reaching the ground water, will move down gradient. If the infiltrating water passed through the landfill the quality may have deteriorated. This infiltrating water will eventually issue into a surface water body. The quality of that ground water will have an impact on the quality of the surface water body. Ground water, of a poor quality, entering a surface water body will have a negative impact if the ground water has deteriorated as a result of infiltration through a landfill. This poor quality surface water could adversely effect secondary and tertiary users of that water.

These secondary and tertiary users of the river water could be for example a public water supply and a sewage works. The treatment facilities of the water works would have been designed to cope with a raw water within a certain quality range. The initial quality of the water entering the water works could be severely reduced as the result of landfill leachate entering the ground water several miles away. Similarly a sewage works pumping effluent into the river would be dependent on the river having a minimum quality of water in order to adequately dilute the effluent. The lower water quality of the river as a result of the landfill several miles away could reduce its effectiveness as a dilute and disperse agent.

Infiltration can have both a positive and negative effect. It is positive where it increases the overall dilution potential of the ground water. It is negative where it increases the overall volumes of generated leachate reaching a water body.

It can be seen from the above examples that all of the flow paths within the hydrological cycle must be understood in order to assess the impact of a landfill on ground water. The EIA of a landfill development should answer all the questions concerning the hydrological cycle such that inputs at any point on the cycle have been considered.

## 4. INFORMATION REQUIRED FOR AN EIA

There is certain information that is required to meet the criteria of Article 25 of S.I. 439 of 1989. This is given below. Each of the headings will be dealt with separately and their bearing on water examined.

An Environmental Impact Statement must include the following information:

1. A description of the development proposed, comprising information about the site and the design and size or scale of the development;

2. The data necessary to identify and assess the main effects which that development is likely to have on the environment;

3. A description of the likely significant effects, direct and indirect, on the environment of the development, explained by reference to its possible impact on:
   (i) Human Beings;
   (ii) Flora;
   (iii) Fauna;
   (iv) Soil;
   (v) Water;
   (vi) Air;
   (vii) Climate;
   (vii) The Landscape
   (ix) The inter-action between any of the foregoing;
   (x) Material Assets;
   (xi) The cultural Heritage;

4. Where significant adverse conditions are identified with respect to any of the foregoing, a description of the measures envisaged in order to avoid, reduce or remedy those effects; and

5. A summary in non-technical language of the information specified above.

Further information can be included with the above such as :

6. The physical characteristics of the proposed development, and the land-use requirements during the construction and operational phases;

7. The main characteristics of the landfilling operation, including the nature and quantity of the materials to be used;

8. The estimated type and quantity of expected residues and emissions (including pollutants of surface water and ground water, air, soil, and substrata, noise and vibration, light, heat and radiation) resulting from the proposed development when in operation;

9. An outline of the main alternatives (if any) studied by the applicant, appellant or authority and an indication of the main reasons for choosing the development proposed, taking into account the environmental effects;

10. The likely significant direct and indirect effects on the environment of the development proposed which may result from

    (i) The use of natural resources;

    (ii) The emission of pollutants, the creation of nuisances, and the elimination of wastes.

11. The forecasting methods used to assess any *effects* on the environment about which information is given under heading 10.

    (Effects include secondary, cumulative, short, medium and long term, permanent, temporary, positive and negative effects)

12. Any difficulties, such as technical deficiencies or lack of knowledge, encountered in compiling any specified information.

### 5.1 HEADING 1 : DESCRIPTION OF THE DEVELOPMENT PROPOSED

This requirement is not of direct relevance to water as its is concerned with the development as a whole. However any location maps should include a small scale map showing the general location of the development and a much larger scale map outlining the site with surface water bodies clearly labelled on it. Houses should also be clearly marked on it. This will enable the statutory body assessing the EIA to get an overview of the area.

### 5.2 HEADING 2 : DATA NECESSARY TO IDENTIFY AND ASSESS THE MAIN EFFECTS

Under this heading topographic and hydrogeological maps should be prepared. The topographic/hydrological map should highlight all surface water bodies including streams and ditches. The flow direction of streams and rivers should also be indicated. Surface water divides should be indicated. This will then define the surface water catchment(s) that are affected by the landfill development.

A hydrogeological map should also be prepared showing all aquifers, ground water abstraction points with abstraction rates, regional ground water flow directions and if possible local ground water flow directions. Positions of springs and turloughs, if present, should also be shown.

All the above maps can be prepared using a combination of aerial photographs, geological field sheets, and field work. The method of preparation should be given in the EIA. A description of how the maps were prepared should also be given. This will enable any statutory body to assess if the appropriate methods were employed in the preparation of the maps and if there were any possible gaps in the data.

The following data and sources of data should have been examined in order to assess the potential impact of a landfill development on the ground water in the area. The following are essentially collected and collated as part of a desk study. Gaps in the data should become apparent requiring additional information :

> Topographic maps and stream flow data for an assessment of the hydrology;
>
> Geology maps to assess quaternary cover, bedrock geology, and geological structures that could control the direction of ground water and leachate movement;
>
> Aerial photograph interpretation to increase the information on the geology, geomorphology, vegetative cover and land use in the area and cultural landscape mapping;
>
> Site investigation records;
>
> Meteorological data to assess rainfall, temperature, potential evaporation, and overall water resources of the area.

Once the desk study has been completed then as part of the assessment of the water resources of the area the following should have been carried out by field work :

A boundary and topographic survey to supplement the O.S maps and aerial photographic interpretation;

Additional geomorphology/geology mapping;

Land and land use survey. This is particularly important as it may identify other possible sources of surface water and ground water pollution that could in the future be blamed upon the landfill development;

Visual assessment of ground conditions;

Detailed ground survey and mapping of significant ecological and cultural detail. This is important from a water point of view as there maybe areas of significant ecological importance that are dependent on a supply of high quality ground water or surface water e.g a marsh or a fen. Similarly cultural features such as houses and farm yards could also be dependent on a wholesome supply of ground water or surface water. In both cases the development of a landfill could compromise the quality of that supply.

Trial pit excavations and drilling investigations should be carried out to draw up composite borehole logs to evaluate the geological, hydrogeological and geotechnical properties of the site. Boreholes are required to determine moisture contents, piezometric levels, permeabilities, water quality, CEC values, strength characteristics etc. for the drift and underlying geology. These boreholes should be drilled into any sand and gravel aquifers and into any hard rock aquifers. They should also be of such a diameter as to permit the insertion of a pump to sample the water quality. These could be nested piezometers. Such a construction would allow monitoring to be more effective.

Some sites may necessitate that either slug tests or pumping tests be carried out to determine the permeability of the aquifer(s), ground water flow directions and any variation of ground water quality as a result of pumping.

Identify and interpret existing and forthcoming regulations from:
EEC
Central government
Local government and local authorities
Planning requirements

The result of examining all the above should lead to the preparation of a base map of existing conditions both on-site and near-site which should include :

Property Boundaries;
Topography and slopes;
Surface water;
Land Use;

The ground water data should be compiled as a series of geological and hydrogeological maps and cross sections for the site and surrounding area, including:

A local well inventory

Preferential flow paths of overland drainage

Location and characteristics of superficial and "bedrock" formations

Occurrence of aquifers

Piezometry

Permeability
Ground water contoured maps;

Ground water flow nets;

Ground water flow paths

Ground water quality (this will include an assessment of quality, if possible, in the vicinity of the existing waste disposal site)

Surface water quality

Details of any ground water abstractions in the area

## 5.3 HEADING 3 : DESCRIPTION OF EFFECTS ON THE ENVIRONMENT OF THE DEVELOPMENT

The importance of water with respect to the flora, fauna and cultural heritage would depend on their use of the water. A large landfill development which generated large amounts of uncontrolled leachate could conceivably lower the water quality over a wide area both in the aquifers and in surface water bodies.

### 5.3.1 Human Beings

This would be of direct relevance if the local inhabitants were using either ground water from a local aquifer that could be affected by the landfill development or if they used a local surface water body for drinking water that could deteriorate in quality as a results of the landfill leachate directly entering the water body or by that water body being a local sink for ground water of a deteriorating quality.

### 5.3.2 Flora

This would be of relevance if the surface or ground water was feeding into marsh or fen areas. Again if the quality of the water had deteriorated as a result of the landfill then it would have a direct impact. Similarly surface water being fed by ground water of a poor quality could deteriorate in quality and so affect the flora.

#### 5.3.3 Fauna

The impact of a landfill on water would be of relevance depending on the use made by fauna of that water. Surface water is classified as being either *salmonid* or *cyprinid* depending on the overall quality of it. Surface water can be further classified by the diversity of macro-invertebrates in the water. A landfill development could have an impact on surface water and as such a base line survey of all surface water bodies shod be carried out as a matter of course. Again ground water of a poor quality issuing into a surface water body could have a detrimental impact.

#### 5.3.4 Soil

This would have a bearing on water if it was acting as an impermeable barrier between the landfill and the ground water or nearby surface water. The soil could also be of importance if it was heavily contaminated by the landfill process such that infiltrating water would become polluted and so pollute the underlying ground water.

#### 5.3.5 The Landscape

A landfill could have a direct impact on the landscape as it is usually locate in a former quarry or sand pit. The original overland flow paths and, perhaps, depending on the depth, the ground water flow direction may have been altered as a result of the excavations. The landfill infills this former "hole" and so once more alters the overland flow directions and perhaps the ground water flow directions.

Waste disposal sites can alternatively be raised sites. In this instance a large embankment of material could be built up on the side of a hill for example. This would have an obvious effect on the local hydrology and hydrogeology. Care would have to be taken to determine exactly how local overland flow paths and the direction of local streams and rivers would be effected by such a development.

#### 5.3.6 The inter-action between any of the foregoing

A qualitative model of the entire system should be developed. The meteorological, topographic, hydrological, geomorphological, geological and hydrogeological inputs should be examined in the whole and a hypothesis put forward as to how a landfill development would impact on water as part of each of these sub-systems. It should set out to try to describe what is happening at present, before the landfill has been developed and then predict what could happen during and after the development of the landfill.

### 5.3.7 The cultural Heritage

The impact of landfill on water in the context of the cultural heritage would be of relevance where water was an integral part of that heritage. Such examples could be an old mill or a holy spring. A spa where people came to take the waters would also be part of the cultural heritage.

## 5.4 HEADING 4 : MEASURES TO AVOID, REDUCE OR REMEDY ADVERSE CONDITIONS

This section deals with the engineering of the site. The hydrogeological investigation should have identified the potential of the site as a landfill. There will be both positive features and negative features. The engineering of the site should include measures to minimise the negative effects and enhance the positive features.

The first step is to determine the likely waste quantities and characteristics using information from existing sites. This in turn will effect the quantities and quality of any leachate generated. If leachate generation is going to occur at a site then the means of controlling it and disposing of it must be included with any EIS. Controlling the leachate generated can be achieved by the following :

Preparative earthworks to build berms around the site and to put top soil to one side for use as capping and intermediary cover during the filling of each cell. The berms will limit overland flow.

Leachate management and landfill gas control and monitoring measures to ensure that leachate generated does not either escape overland from the landfill or begin to migrate down through the underlying soil and into the ground water.

Site preparation for lining and site lining are usually the norm. Lining the site is now considered, at present, the most effective means of controlling the movement of leachate either out of the landfill by flowing overland or out through the base of the landfill.

Under-drainage should be included if the site is to be lined. This will collect any leachate generated in a cell and direct it to a common sump where the leachate can be removed and subsequently treated.

Optimum landfilling method evaluated should be based on the the overall hydrogeological setting of the landfill. This in turn will dictate the optimum cell size such that it will be be economically viable and only open for as short a time as possible. The cell configuration and phasing of development and restoration will be important in terms of minimising the impact of the landfill on the local water resources.

Interim cover soil thickness and final cover capping and soil thicknesses are also essential from the point of view of again minimising the amount of leachate generated. This will occur during the lifetime of each cell and afterwards when the cell has been filled.

Surface drainage is of particular importance. Surface drainage will be required within the landfill during development. The quality of the water on the surface will be determined by the flow path of that surface water. Surface water originating within the landfill maybe of a poor quality. This water will have to be intercepted by drains and channelled away for treatment. Surface water originating from capped cells will likewise have to be intercepted to ensure that it does not flow directly into a surface water body and introduce either large amounts of silt and sand, fly litter or water of a poor quality.

Many landfill developments do make for the provision of intermediate and final capping material. However the volumes of material required may not readily available at the site. This requires locating capping material elsewhere. Therefore the volumes of material required should have been calculated and if necessary sourced outside the landfill site.

The final restoration contours and landscaping is important as it will control the amount of precipitation that will infiltrate into the landfill, flow off the capped landfill and the direction of that flow. It is also important to ensure that the water balance is not upset in sensitive bog, marsh or fen areas nearby. Large amounts of overland flow could carry material in suspension and solid debris from the landfill site.

Monitoring wells for leachate and landfill gas are critical. There should be a design for both included with the EIS. The design should be such that the monitoring wells can be sampled with ease. Ideally each monitoring borehole should be nested such that samples can be taken of the ground water at various depths. This will provide information both on the level of contamination and at what depth it is occurring. The position of the wells should be such as to intercept ground water flow moving down gradient of the landfill. The boreholes should be located close enough to the landfill such that the presence of pollutants can be detected before it is too late. There should also be several boreholes up gradient of the landfill to act as control wells for the overall background water quality.

Designing and implementing a regular water quality monitoring programme of both surface water and ground water is essential. The parameters to be monitored should be listed. The frequency of that monitoring should also be given. Trace organics should be analysed for at least once every year. A table of recommended parameters is given in Table 5.1 with the monitoring frequency. The data should not be simply collected and stored away but rather provision should be made for that data to examined annually and a brief report prepared.

It is recommended that the ground water and surface water should be sampled at monthly intervals from the start of the development until leachate generation from the site has ceased, and chemical analysis of the samples carried out. A more rigourous analysis should be carried out four times a year to correspond with the following :

a) Before the Autumnal recharge e.g. early September

b) After the Autumnal recharge e.g. November/December

c) At the end of the winter e.g. February/March

d) In early summer e.g. June

The monthly analysis will incorporate the following parameters:

Table 5.1

| | |
|---|---|
| **pH** | **Eh** |
| **Temperature** | **Alkalinity** |
| **Conductivity** | **Sulphate** |
| **Ammonia** | **Chloride** |
| **Nitrate** | **Sodium** |
| **Nitrite** | **Potassium** |

The more intensive quarterly analysis will also include:

| | |
|---|---|
| **Chemical Oxygen Demand (COD)** | **Biochemical Oxygen Demand (BOD)** |
| **Total Organic Carbon (TOC)** | **Calcium** |
| **Magnesium** | **Iron** |
| **Manganese.** | |

## 5.5 HEADING 5 : NON TECHNICAL SUMMARY OF DATA COLLECTED

This should be used as an opportunity to put forward a semi-quantitative model of the likely impact of the landfill on the local environment. As required the model should be described in clear non technical terminology. In this section a model of the hydrogeology of the area could be put forward. The model will draw together all aspects of the data collected. It should integrate the topography, geology, hydrology, hydrogeology and site investigation data into a single system.

The model could have the form of describing the amounts of precipitation and what happens to it once it reaches the ground. It could then be further developed to predict how the precipitation will interact with the local ground water and the waste in the landfill. Ground water flow rates and dilution factors should be given. Overland flow paths should be described and incorporated into the model.

Finally attention should be drawn to the probable scenario that would occur if leachate did escape from the landfill whether by overland or through the base of the landfill. The risk of this occurring should be quantified and provisions included for the remediation of the site in the event of a deterioration of the environment as a result of the landfill development.

Headings 6, 7,8,9, 10 and 11 have been addressed within the context of the above headings.

March 1991.

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# MINING, QUARRYING, GROUNDWATER AND ENVIRONMENTAL IMPACT ASSESSMENT

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## INTRODUCTION

Investigations similar to E.I.S.'s have been carried out for mining projects in Ireland over the last 20 years as part of the planning and mining lease process.

Up until the investigations for the proposed Tara mine the impact on groundwater was largely ignored. At Navan the concern with groundwater was mainly to do with the possible inflow of water from the overlying River Blackwater via an old channel (Whistlemount) infilled with unconsolidated material. There appears to have been little concern with the impact of dewatering the orebody and ancillary area down to a depth in excess of 400m with the resultant extensive cone of depression. Groundwater was considered in a report (1982) on the proposed 'Opencast' Gypsum mine at Knocknacran in County Monaghan.

In 1989 the Minister for Energy adopted a new position which meant that no new mining leases would be granted until the E.I.A. process was carried out. Since then some six projects have been dealt with, another five are in the pipeline and we anticipate a few more will come in over the next 18 months. It is interesting that the first major project to be considered (the Conroy orebody at Galmoy) has a major groundwater impact as it is located in an important aquifer.

In Ireland water is the principal medium by which contaminants move away from mines and quarries. In nature groundwater and surface water are inextricably interlinked and this is quite evident when dealing with mines and quarries. This lecture is mainly concerned with groundwater although some important aspects of surface water will be mentioned from time to time.

In this lecture, it is intended to provide those with responsibility for preparing scoping documents for mining/quarrying projects with the necessary background groundwater data and the relevant information required to carry out an adequate EIA of the groundwater component of these type of projects.

## LEGISLATION AND REGULATIONS

In Ireland, mining is regulated by the Department of Energy under the Minerals Development Act, 1940 and subsequent amending legislation up to 1979. Under this legislation the Minister (and Mining Board) has wide powers (Section

80) to control most aspects of mineral exploration and development.

The Act refers to Scheduled Minerals (see Appendix I for a list). The word mineral (includes all Scheduled Minerals) is defined in Section 3 of the Act as:

> "All substances in, on, or underland, whether obtainable by underground or by surface working, and includes all mines, whether they are or are not already opened or in work and also includes the cubic space occupied or formerly occupied by minerals".

The Act specifically excludes "the Agricultural surface of the ground" and "turf or peat". The 1979 Act also excludes stone, gravel, sand or clay. A number of Ancillary Rights which deal with various aspects of water in a mine are dealt with in Section 6 subsections (e), (f), (g) and (h).

Since the Summer of 1989 the Department of Energy has been operating on the basis of a reply given in the Dail by the Minister which stated that he would not grant a mining lease unless a "full and detailed EIA had been carried out by an independent expert acceptable to him". The Minister has also stated that no mining lease will be considered unless a company has full planning permission and other development consents such as Effluent Discharge Licences etc.

The European Communities (E.I.A.) Regulations 1989 (S.I. no. 349 Department of the Environment) gives effect to the EC Council Directive (No. 85/337/EEC) in Irish law. Article 24, Part II, subsections 2(a), (c) and (d) of these regulations provide for the inclusion (in the EIA process) of projects involving:-

- Peat extraction for a new or extended area of 50 hectares,
- All extraction of minerals (no minimum threshold size) within the meaning of the Minerals Development Acts, 1940 to 1979,
- The extraction of stone, gravel, sand or clay from an area greater than 5 hectares.

Part II, subsection 18(2)d of the Local Government (Planning and Development) Regulations, 1990 (S.I. No. 25) directs a Planning Authority to send a copy of an E.I.S. which relates to the extraction of minerals within the meaning of the Minerals Development Acts, to the Minister for Energy.

Footnote: For the purposes of this lecture the word mine refers to the working of Scheduled Minerals and the term quarry to the working of bulk rock such as road metal, ground limestone etc.

## HYDROLOGIC CYCLE

When considering the impact of mines and quarries on groundwater there are a number of important characteristics of the hydrogeologic regime in Ireland which should be borne in mind. They are;

(1) major aquifers cover about a quarter of the island,
(2) recharge is plentiful and well distributed throughout the year,
(3) storage in the aquifers is relatively low and throughput is quite rapid in the two most extensive aquifers,
(4) flow paths are shallow and short,
(5) water tables are generally within 10m of the surface although there are a few areas that are notable exceptions, and
(6) water quality is generally good.

## GENERAL IMPACT OF EXCAVATION PROJECTS ON GROUNDWATER

When considering the scoping of a mining/quarrying project it is necessary to have a general feel for the effect the proposed operation will have on the particular environment in question. The hydrogeology of an area can be affected in four ways:

(1) Changes in the storage and permeability of an aquifer,
(2) Alteration of direction of groundwater flow and reduction in water level on a temporary or permanent basis,
(3) Reduction in the quantities of water recharging an aquifer, and
(4) Changes in groundwater quality.

All mining/quarrying excavations affect the water environment (surface and subsurface catchments) in which they occur. Surface and groundwaters will enter the excavations in varying proportions. The relative proportions of both are dependent on the type and extent of the mine/quarry and the geology/hydrogeology of the surrounding area. Furthermore these proportions may change (as may concern about the type of impact) over the full life of the excavation (i.e. from premining-mining- to rehabilitation). The inflow of both types of water can generally be prevented or at least limited. However water arising within the excavation must be contained and controlled within it.

During the operational phase of all mines/quarries, water will either have to be pumped or will move naturally underground. The principal impacts on the water environment are dependent on the relevant alternative. If water is to be pumped, a groundwater quantity impact and a surface water quality impact are likely to be the most significant. If water moves underground, the situation will be reversed. When an operation is completed the impacts may change.

The extent and type of impact on groundwater that results from an excavation will depend on a number of factors which are a function of the particular mine/quarry such as the type of operation proposed (opencast or underground), the material to be worked, its horizontal and vertical extent and local topographical situation etc.

## HYDROGEOLOGICAL ENVIRONMENTS

For the purposes of examining the likely impacts of mining/quarrying on groundwater the subsurface environment can be divided into four main categories based on two criteria which are;

(1) the hydrogeological classification of the geological strata which is to be worked or hosts the mineral to be worked (i.e. an aquifer or an aquitard)
(2) whether the bulk of the operation is in the saturated or unsaturated zone (i.e. above or below the water table).

Most mining/quarrying projects in Ireland for which an EIS is required will fall into one of the categories outlined below.

(a) An aquitard in the unsaturated zone.
(b) An aquitard in the saturated zone.
(c) An aquifer in the unsaturated zone.
(d) An aquifer in the saturated zone.

Further details on each category, the differences and significance of the groundwater impact and examples will be given in the course of the lecture.

## SCOPING THE GROUNDWATER COMPONENT

The EIA process is in the early stages of development at present with developers and regulators feeling their way through the regulations and adopting rules, procedures, interpretations etc. as they go along. In time the system will settle down with the regulators knowing what they want and the developers realizing what they have to provide.

At the start of an EIA the Planning Authority should try to get a general feel for the project and the likely significant impacts as quickly as possible. It is important that the regulators and developers get together early in the design stage to scope a project in order that there is sufficient time to collect and compile the necessary data and for the concerns raised by the Planning Authority and other relevant agencies to be incorporated in the completed project design.

The Department of Energy is taking an active role in scoping and assessment of EIS's at the planning stage in order to try to avoid duplication at the subsequent mining lease stage.

From the groundwater stand point a general philosophy must be adopted which seeks to minimize the impact as far as practical;

i.e. only the minimum amount of contaminated water should be allowed to enter the groundwater body,
- only the minimum amount of clean groundwater should be allowed to come in contact with contaminated geological strata,
- and as little groundwater should be pumped as practical.

### Topics to be covered

Many of the topics to be covered in scoping the groundwater component of a mining/quarrying proposal will be similar to those for other projects involving groundwater such as;

(1) A project description,
(2) The general geological/hydrological/hydrogeological setting of the area and a detailed description of the local project area,
(3) The relationship/hydraulic connection between the space occupied by the project and the groundwater body,
(4) The impact on the groundwater body in general and nearby wells, springs and discharge of baseflow to watercourses in particular,
(5) How it is proposed to minimize the impact on the items mentioned above in (4) during each phase of the project,
(6) A survey should be carried out, of all wells, boreholes and springs likely to be affected by the physical dewatering associated with the project and/or contaminated groundwater either during the life of the project or after it terminates, and
(7) The scoping document should request details of the system proposed to monitor groundwater levels, flow and quality both during the project and after it terminates.

Saturated Zone

The following is a list of information that will generally be required for mines/quarries that will necessitate significant quantities of water being abstracted by pumping. Obviously the breath and depth of reply expected will depend on the size and nature of the project and the sensitivity of the particular environment.

(a) The quantity and quality of water to be pumped and how it will vary both annually and throughout the life of the project.
(b) How will the cone of depression develop over time?
(c) The impact on the groundwater body should be investigated over the estimated area of the cone of depression plus an amount (say 25%) to allow for error.
(d) The consequences for the overall hydrogeological regime of the reversal of the hydraulic gradient e.g. on springs and baseflow discharge etc.
(e) The effect of dewatering on ground stability (i.e. subsidence and on any karst features) and wetlands.
(f) After the working terminates what effect will the rebound of the water table have on the surface and subsurface flow system, land use and buildings etc.
(g) The long term movement of contaminated groundwater away from the workings.
(h) What steps will be taken to cover the surface of the disturbed geological strata and/or prevent interreaction with infiltrating waters.
(i) Details of the quantity and quality of the receiving waters their natural variation and the ability of these waters to assimilate the mine/quarry discharge.

Unsaturated Zone

For mines/quarries mainly in the unsaturated zone the following information will be required;

(I) The steps to be taken to reduce, control and treat the surface water in the excavation, and
(II) What will be the quantity and quality of water that will infiltrate into the groundwater body both during the project and after it terminates.

For projects in either situation a complete list of all chemicals (including petroleum based products), to be used in areas where the ground is to be disturbed, should be provided. Details should be given of measures to be taken to prevent these substances gaining access to the groundwater body.

## CONCLUSION

The environmental damage caused by mining/quarrying in the past will no longer be tolerated. All relevent aspects of the environment must be considered when looking at an extractive project where groundwater is generally not out of sight!

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(This is an extended abstract of a lecture given to the IAH meeting in Portlaoise in April 1991. Figures and slides were included in the lecture. This lecture was one of a series at the meeting dealing with E.I.A. Legislation and various aspects of E.I.A.'s and groundwater).

APPENDIX I

[1940] Minerals Development Act; 1940 [No. 31]

## SCHEDULE

### List of Minerals

Alum Shales.
Anhydrite.
Antimony, Ores of.
Apatite.
Arsenic, Ores of.
Asbestos minerals.
Ball clay.
Barytes.
Bauxite.
Beryl.
Bismuth, Ores of.
Bitumens.
Calcite.
Chalk.
China Clay.
Chromite.
Coal.
Cobalt, Ores of.
Copper, Ores of.
Corundum.
Cryolite.
Diatomaceous Earth.
Dolomite and Dolomitic Limestone.
Feldspar.
Fireclay.
Flint and Chert.
Fluorspar.
Ganister.
Gem Minerals.
Gold, Ores of.
Graphite.
Gypsum.
Iron, Ores of.
Kaolin.
Laterite.
Lead, Ores of.
Lignite.
Lithomarge.
Magnesium, Ores of.
Magnesite.
Manganese, Ores of.
Marble.
Mercury, Ores of.
Mica.
Minerals Oils.
Mineral Pigments.
Molybdenite.
Monazite.
Natural Gas.
Nickel, Ores of.
Oil Shale.
Platinum, Ores of.
Potash Minerals Salts.
Quartz Rock.
Radioactive Minerals.
Refractory Clays.
Rock PHosphates.
Rock Salt.
Roofing Slate.
Serpentinous Marble.
Silica Sand.
Silver, Ores of.
Strontium, Ores of.
Sulphur, Ores of.
Talc and Steatite or Soapstone.
Tin, Ores of.
Titanium, Ores of.
Tripoli.
Tungsten, Ores of.
Witherite.
Zinc, Ores of.

ENVIRONMENTAL IMPACT ASSESSMENTS AND GROUND WATER:
THE UNITED STATES EXPERIENCE

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# ENVIRONMENTAL IMPACT ASSESSMENTS AND GROUND WATER: THE UNITED STATES EXPERIENCE

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## ABSTRACT

Reviewing the potential effects on ground-water availability and quality from a proposed project is an essential part of sound environmental impact assessment (EPA) in the United States. Under the National Environmental Policy Act and other provisions of Federal law, both formal and informal procedures have been established for these analyses. Example categories of activities addressed include housing developments, highway and airport construction or modifications, energy projects, and pesticide application programs. It is clear that if EPA procedures are fully integrated into project planning, improvements in ground-water protection will result.

## INTRODUCTION

One of the most important developments in the field of environmental protection in the United States came in 1969, with the passage of the National Environmental Policy Act. NEPA established not only a procedure for reviewing the overall effects of Federal actions on the environment, but a precedent for examining a wide range in both direct and indirect issues relating to development. Even with the more than 20 years of experience with NEPA, our ability to accurately assess potential physical and chemical changes to ground water resources is still improving. The focus of this paper is to present a general overview of the impact assessment process in the United States and concentrate specifically on project actions for ground water.

## THE E.I.A. AND E.I.S. PROCESS

One of the most insightful reviews of the differences between Environmental Impact Assessments (EPA) and Environmental Impact Statements (EIS) is presented by Kennedy (International Environment Reporter, v. 11, n. 4, 1988). He uses the term EPA to apply to the "process of examining an activity for its environmental effects prior to making a decision on its implementation." Thus it is a more generic term than EIS which is "a document or report that contains an analysis of the information gathered through carrying out an EPA."

According to Kennedy (1988), the United States (along with the Netherlands and perhaps Canada), follows a "formal-explicit" approach, whose salient features are;

o EPA requirements are codified through legislation or regulations.

o Reports such as EISs are prepared summarizing the outcome of the EPA/EIS process.

o Accountability is required to ensure via administrative or judicial review, that EPA results had been taken into account in decision making.

A more "informal-implicit" approach is used in Great Britain, Germany, and Scandinavia. Kennedy believes that either the formal-explicit or informal-implicit models can be used successfully to help guide environmentally-sound development. An informal approach, for example, can provide the flexibility to take into account unique project situations, field conditions, and administrative factors. For either approach to work, however, there must be a clear integration into actual project planning itself. Kennedy references studies which show that EPA costs usually average 0.1 to 1.5 percent of overall costs. There is some experience that overall project cost savings can result from the more open review of options that EPA procedures foster.

A schematic of the formal NEPA process used in the United States is exhibited in Figure 1. Some of the salient points to note include:

o the use of an Environmental Assessment (EA) to ascertain if projected impacts are expected to be significant enough to warrant a formal EIS.

o the use of a "categorical exclusions" or "Finding of No Significant Impacts (FNSI)", to essentially bypass a process not deemed relevant.

o the several-stage approach to actual EIS preparation; highlighted further in Figure 2.

Of particular importance is NEPA scoping, which allows the early identification of technical and policy issues, data gaps, and study needs.

## EXAMPLE GROUND-WATER ISSUES IN E.I.A.s

The U. S. EPA's Office of Federal Activities keeps track of Environmental Assessments and Impact Statements. An informal survey of staff in that Office was conducted in connection with this paper. Staff report that some of the key ground-water related questions which have arisen in reviewing other Federal agency actions under NEPA and related programs (in no particular order of occurrence) include:

o Irrigation Projects:

One irrigation-related project considered in EISs is the salinity-control program administered by the Departments of Agriculture and Interior. Although ground water is not usually the focus of such reviews, the environmental impact would entail the drawdown of the tapped aquifer. Mitigating steps that are being considered include limiting the amount of area irrigated or the amount of water drawn, and implementing water conservation measures.

In another case, the Bureau of Reclamation (BuRec) is examining the treatment of irrigation return flows by passing them through manmade wetlands. The wetlands in turn are used for ground water injection, and municipalities are able to tap into the surplus ground water as a way to help meet their water needs. This re-use technique can be a form of mitigation for site-specific projects.

o Flood Control Projects:

Flood control projects such as channelization, for example, can reduce recharge to ground water. Increased likelihood of salinity incursion into the ground water can result. In addition, ground water problems can occur on a region-wide scale as a result of projects to facilitate drainage, such as the straightening of river tributaries. These projects can reduce the surface area available for percolation. One example of mitigation suggested was the building of percolation ponds in selected concrete channels. The ponds are not filled with concrete, and thus the surface water which collects in them is able to percolate to the water table.

o Surface and Underground Coal Mining:

Acid mine drainage and sedimentation are the major water quality problems caused by coal mining activities. When coal is mined, previously protected strata are exposed to oxygen and --in the case os surface mines -- to direct weathering as well. When water and oxygen come into contact with iron disulfides, they oxidize and release sulfuric acid and ferrous sulfate. These oxidation products (acid mine drainage) will eventually enter into streams and ground water. Erosion and sedimentation may also be caused by improper design, construction, and maintenance of access and coal haul roads. Some of the measures to control acid-mine drainage include diversion ditches that prevent water from entering the mining area or carry it quickly through the area, stream diversions, sedimentation ponds, and terraces that intercept run-off. Drainage facilities are usually constructed to control the run-off from haul roads.

o Highway Projects:

The primary direct impacts associated with highway construction activities include soil erosion and sedimentation increased surface runoff due to the clearing of vegetation, nonpoint source discharges entering ground water, and changes in stream and river flow and channel morphology caused encroachment. Ways of responding to highway-project impacts include designing and implementing erosion and surface run-off control and monitoring measures to comply with water quality standards.

o Hazardous Waste Projects:

EISs are routinely prepared on hazardous waste production generated by the Department of Energy (DOE) or the Department of Defense (DOD) programs. Although impacts to ground water are reviewed through EISs, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the "Superfund" actually defines the cleanup actions required if the waste has already been produced. For present and future hazardous waste production the Resource Conservation and Recovery Act (RCRA) defines the requirements.

o Pesticide Application Plans:

In the last two years, several different federal agencies have submitted environmental impact statements (EISs) involving the use of pesticides. These vary from the Bureau of Land Management's (BLM) consideration of herbicide use in a vegetation management program in 13 western states to the Animal and Plant Health Inspection Service's (APHIS) consideration of insecticide use for the Boll Weevil eradication program. These two programs use of pesticides were considered a potential risk to ground water. Measures suggested to mitigate for these impacts included restricting the pesticide's use near areas where it could cause ground water contamination, the use of less harmful pesticide products, and the use of alternative control measures.

## E.I.A. ANALOGIES IN OTHER U. S. PROGRAMS

While the NEPA process is the most well known of EPA type actions in the United States, it is fair to say that "EPA thinking" has affected many other non-NEPA programs. The Office of Ground-Water Protection, for example, implements requirements under the Safe Drinking Water Act to review Federal financially-assisted projects for their impact on designated "Sole Source Aquifers (SSAs)". More than 50 SSAs have been designated around the United States, with the primary criterion being that the aquifer serves more than half of the drinking water needs of area residents. While the Agency believes that Wellhead Protection Areas represent hydrogeologic settings of greater importance for protection measures than Sole Source Aquifers, the "post-designation project review" requirements of the SSA effort offers a good insight into a more informal EPA-type approach in that:

o A large number of potential projects must be screened to a manageable number for closer scrutiny.

o Limited staff resources and analytical tools are available.

o The applicant (usually a Federal or State agency) will not fund unlimited studies in support of EPA comments; they must be convinced of the merit of the review comments.

Table 1 is a summary of the 153 EPA-like project reviews conducted by the Office of Ground-Water in the 10 Regions during a one-year period ending September 30, 1990. These projects are associated with more than $500 million of Federal funds. The projects carried out by Federal agencies with potential ground-water concerns are similar in scope to those covered under NEPA, and include:

o Department of Housing and Urban Development -- primarily construction of houses, apartments, etc..

o Department of Transportation -- notably road construction, revitalizations, airport expansions, etc.

o Department of Agriculture -- primarily loans for farmers to develop or improve agricultural homesteads or crop acreage.

An obvious question is what effects the reviews have had on the outcome of the decision. An important point is that the largest number of projects (133) were approved without modification from the review. None were denied as a result of the review, but 20 were modified to reduce impacts on ground water in such ways as to:

o Modify the direction and manner of highway drainage away from municipal wellfields.

o Reduce the number of drainage basins in vulnerable areas.

o Install expanded monitoring networks.

o Modify construction and monitoring of dairy waste lagoons.

o Replace on site septic systems with more advanced treatment due to already high levels of shallow ground water contamination.

o Institute contingency measures for spills in new business centers.

o Conduct follow-up studies on the impacts of dredged materials proposed for disposal on alluvial aquifers.

o Foster augmentation of surface water flow due to decrease in ground-water recharge from septic tank banning.

As can be seen from these examples, the advantage of both the formal EPA/EIS procedures, and the more "informal EPA-like" procedures of the SSA reviews, is that a number of previously unaddressed but critical ground-water protection issues were raised and resolved.

## ACKNOWLEDGEMENTS

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Figure 1

General Process for Implementing Environmental Impact Statement Requirements of NEPA in the United States

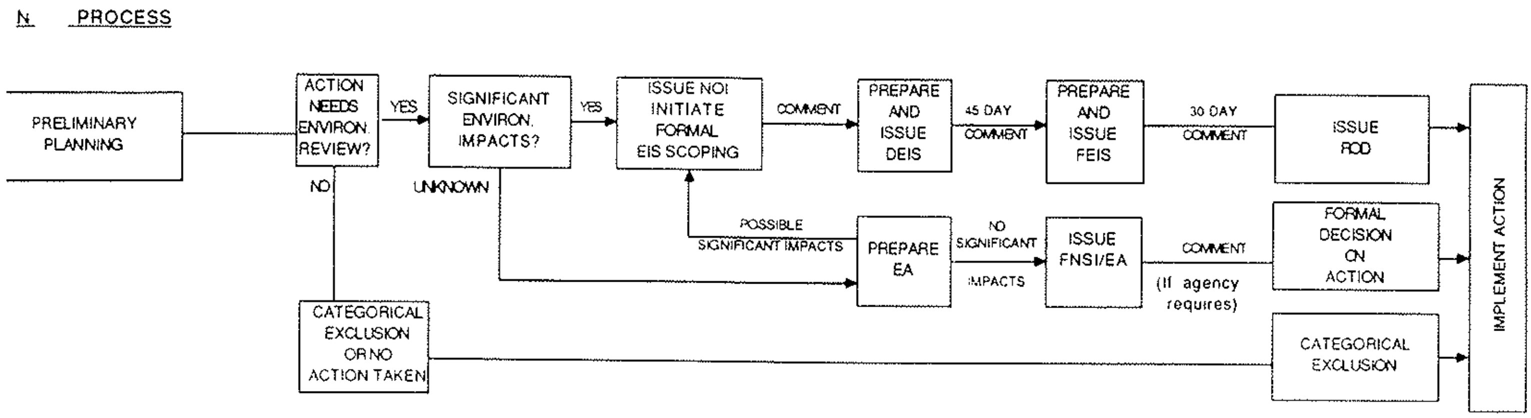

Figure 2

Stages in Environmental Impact Statement Preparation

| NEPA ELEMENTS |
|---|
| Need for project identified |
| NEPA Scoping<br><br>o Issue Notice of Intent to prepare EIS<br>o Invite participation of interested parties<br>o Determine scope of the significant issues<br>o Allocate assignments between lead and cooperating agencies<br>o Identify other environmental review requirements<br>o Set time limits<br>o Public meeting optional; may be integrated with any other early planning meeting |
| Draft EIS<br><br>o Describes purpose and need<br>o Presents "reasonable" alternatives including the proposed action<br>o Describes affected environment<br>o Discusses environmental consequences, including direct, indirect, and cumulative impacts, socio-economic impacts, historic and cultural resources, and mitigation<br>o Presents list of preparers<br>o 45-day public comment period |
| Final EIS<br><br>o Must contain responses to comments received<br>o 30-day waiting period during which comments may be received |
| ROD<br><br>o Describes commitment(s) to mitigation measures |
| Overall Time: 18 months |

Table 1

Summary of EIA-Like Reviews Conducted by EPA Regions Under Sole Source Aquifer Post Designation Provisions

| FEDERAL AGENCY | NO. OF AGENCY PROJECTS REVIEWED BY REGIONS |
|---|---|
| DEPARTMENT OF COMMERCE (DOC)<br>Economic Development Agency | 4 |
| DEPARTMENT OF DEFENCE (DOD)<br>National Guard Board<br>United States Army Corps of Enginners | 2 |
| DEPARTMENT OF ENERGY (DOE)<br>Federal Energy Regulatory Commission | 5 |
| DEPARTMENT OF THE INTERIOR (DOI)<br>National Seashore | 1 |
| DEPARTMENT OF TRANSPORTATION (DOT)<br>Federal Avation Administration<br>Federal Highway Administration | 33 |
| DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD) | 72 |
| DEPARTMENT OF AGRICULTURE (USDA)<br>Farm Housing Administration | 26 |
| US ENVIRONMENTAL PROTECTION AGENCY (EPA) | 10 |
| TOTAL | 153 |

# WELLHEAD PROTECTION IN THE UNITED STATES

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# WELLHEAD PROTECTION IN THE UNITED STATES

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Washington DC

## ABSTRACT

More than 30 States in the United States are developing programs to delineate and manage Wellhead Protection Areas (WHPAs) for public water supply wells. The U.S. Environmental Protection Agency provides the States with technical assistance documents, training courses, analytical modeling packages, and applied research results, to meet this goal. WHPAs are established through the use of technical "criteria" and "methods". The States tend to choose a combination of these to protect wells from both microbial and chemical threats. About two-thirds of the States use time-of-travel criteria; most of which fall in the 2 to 10 year range, with a few selecting the more protective 20 year or greater range.

Relative to methods, the States have generally selected more sophisticated approaches than anticipated. Volumetric flow calculations, analytical models, and hydrogeologic mapping are the most common methods. Numerical modeling is also used by some cities and towns on some specific protection areas of high value and importance.

There is a wide range of approaches used to provide greater protection to wellhead areas. These include all aspects of permitting, inspection, education and technical assistance.

## INTRODUCTION

Providing clean drinking water to our citizens and protecting this quality for future generations have always been high priorities for environmental programs in the United States. The Safe Drinking Water Act is the basic law regulating centralized public water systems based on either ground water or surface water. Under this Act EPA sets maximum concentration levels for water delivered to the public, and provides controls to ensure safe disposal of wastes through injection wells.

In 1986, the Act was amended to include a new activity; the Wellhead Protection Program. The hydrogeologic aspects of the program are being carried out by the U. S. Environmental Protection Agency and the individual States. Most of the laws in the United States that relate to ground water quality are written to control specific land use activities such as injection wells and contaminated waste sites.

The Wellhead Protection Program takes a different approach by looking at the ground-water resource on a broader basis. Stated simply, the Program requires our States to map or, as we say, "delineate" areas of recharge to existing and new wells, and then ensure that land use activities within the delineated area, or near the area, will not lead to contamination of the wells. By looking first at the ground-water resource, we are able to examine in a more integrated fashion a larger group of potential pollution sources such as industrial sites, transportation centers, agricultural areas, fuel storage facilities, or even storm runoff from highways which can affect adjoining wellfields.

The Office of Ground-Water Protection in the Environmental Protection Agency helps our States carry out this responsibility. The Office helps in such ways as:

o Providing money for States to hire technical staff or conduct field studies.

o Developing technical materials such as handbooks, workshops, training courses and computer software.

o Working with the States to solve particular technical or administrative problems.

More than half of the States are expected to have an EPA-approved program in place for wellhead protection by the end of calendar year 1991.

## WELLHEAD DELINEATION CRITERIA

Wellhead protection "criteria" are the basic hydrologic factors which define the zone and "methods" convey the technical procedure used to transform the criteria to a line in the field or on a map. Some of these concepts are depicted in Figure 1. The criteria depicted here include the cone of depression (more properly called the zone of influence), all or part of the zone of contribution (frequently subdivided by time-of-travel zones), and ground-water divides or hydrogeologic boundaries. Hydrogeology plays a significant factor. In Figure 1, for example, the zone of contribution of the well will be a more appropriate protection area than the zone of influence, due to the regional slope of the watertable.

Regional hydrogeology is similarly important. The flow boundaries criterion is common in the glaciated Northeastern United States, where small aquifers with visible boundaries are prevalent. The hydrogeologic mapping method used in conjunction with the boundaries criterion, utilizes the expertise not only of hydrogeologists, but of geomorphologists and biologists. The same approach is used in other areas of the United States, including conduit karst and fractured bedrock.

A more complex example is seen in the approach taken by one of the fastest growing areas of the United States, Miami, Florida. Miami's growth in population, business, and industry is also placing great stress on water availability and quality. To meet this demand, local officials have been setting new well fields. The Northwest Wellfield, for example, is one of the largest in the United States. Each of the wells in this field can pump as much as 50 million liters a day.

Two factors present complications. First, the watertable of this loosely consolidated carbonate aquifer, though of low regional slope, is often within 1 to 4 meters from the land surface; a naturally vulnerable setting for the entry of contaminants. Second, industrial and agricultural sources of pollution already have degraded the aquifer, posing threats to the protection area along the eastern side. Since the limits of the aquifer extends more than 100 kilometers and the watertable is nearly flat, the flow boundaries criterion selected in the Massachusetts example would be impractical here.

Given these conditions the wellhead protection area was determined through a combination of criteria. The outermost boundary generally coincides with the 40 year equal time-of-travel line. Due to the importance of the wellfield, such setback zones or retention times are considered necessary. Hence, one can say they use a "time-of-travel criterion", with a "criteria threshold" of 40 years. An inner protection zone based on a 210 day criterion has also been adopted to guard against more immediate hazards. As a further measure of the wellfield's importance, technical staff collected considerable field data, ran a series of pumping tests, and used a sophisticated numerical model as the method of choice.

An interesting technical story relates to the influx of contaminants from hazardous waste sites on one side of the protection area. By adjusting pumping rates of these and neighboring wellfields, as well as through the construction of surface water drains, the eastern boundary of the wellfield will be hydrologically changed to provide a wider buffer zone from these contamination sources.

The basic delineation criteria are: distance from the well, drawdown of the water surface, time of travel to the well, flow boundaries, and the assimilative capacity of the aquifer system. All but the last criterion is being used. Of our 30 States actively developing programs, most are using a combination of criteria and thresholds. Approximately two-thirds of the States are using the time-of-travel criterion; most associated with a 2 to 10 year threshold range. Fewer States than expected have selected the simpler distance criterion; those who do tend to select 1 kilometer or less as the threshold. While we are very encouraged that so many States are implementing wellhead programs, we are urging them to be more protective by adopting larger thresholds such as 10 to 20 years time-of-travel, or 2 to 4 kilometers in distance.

## WELLHEAD DELINEATION METHODS

Relative to methods, the States are generally selecting more sophisticated approaches than we initially expected. We see extensive use of analytical models for example. In response to this trend, the Office of Ground-Water Protection has just developed a sophisticated, easy to use personal computer software package which is receiving much attention. In only 5 or 10 minutes, the protection area for many wellfields can be determined. Input parameters can be easily changed to examine the effects of increased pumping, aquifer boundaries and heterogeneities, and other factors. The model is also capable of analyzing data uncertainties, where confidence levels on a delineated area are displayed.

## NEW DEVELOPMENTS FOR CONFINED AND FRACTURED ROCK AQUIFERS

While many States have moved ahead with protection programs for wells in porous media aquifers, there is great interest in applying customized approaches for other settings. Hydrogeologic technical assistance and applied research at the Office of Ground-Water Protection has been focused on this problem for the last two years.

Classic geological training has supported the idea that "artesian" or "confined" aquifers are not subject to contamination from the surface, due to supposedly protection of the aquifer by layers of low permeability. Recently, however, we have learned that very few wells are truly "highly confined"; most in fact are "semi-confined" in such a way that porous media methods can be used. Even in "highly confined" settings, simplified protection areas can be drawn to help locate natural and human-induced breaks in confinement which can allow contaminants to move downwards from the surface.

Fractured media aquifers are particularly important as a source of water supply for small communities and towns in many parts of the United States. While research in support of the nuclear waste program has fostered the development of highly sophisticated models for these settings, much simpler and less costly approaches are needed for community water supply protection. A key question in such settings is whether the scale of observed fractures (as determined in outcrop, through remote sensing, or through subsurface log interpretation) is much less than that of the scale of the problem. Under these conditions, the area can be considered as a porous media equivalent. Where the anisotropy of the fracturing predominates at problem scale, then geologic mapping will normally be carried out to approximate the protection area.

## SOURCE IDENTIFICATION AND MANAGEMENT

Wellhead protection connotates much more than a straightforward modeling or mapping of recharge areas to wells. The most perplexing problems relate to which potential sources of contamination should be examined and managed differently as a result of the public water supply threat. Planners and government agencies charged with implementing wellhead programs are faced with such difficult questions as:

- What is the relative risk among the many potential contamination sources to local water supplies? Do industry, government, and the public agree on the risks?

- What is the appropriate balance between regulatory approaches and education efforts?

- How can land use controls be "phased-in" to cover existing facilities in addition to new facilities?

- What incentives can be provided for local communities to move forward with protecting individual wells?

- What user fees, service fees, taxes, and other means of generating local revenue can be used to build resources for protection efforts?

## FINDING NEW ANSWERS THROUGH RESEARCH

As our States and localities move ahead with protection based on today's knowledge, EPA's research program on wellhead protection is helping provide answers for tomorrow's questions. The program encompasses 6 topics:

- Delineation method testing and improvement - through field work and computer analyses.

- Assimilative capacity - examining how contaminant transport factors can be incorporated in our modeling work.

- Multiple source risk analysis - looking at the relative importance of different categories of contamination sources.

- Wellhead protection in agricultural areas - reflecting the more diffuse nature of the problem.

- Monitoring strategies - to give advance warning so that preventive actions can be taken.

o Technical assistance and technology transfer - our responsibility to make sure that the advances of science are expressed in ways and forms that can be used by our cities and States.

On the topic of technology transfer, our research program is helping to resolve some of the ongoing conflict between science and practical implementation when establishing specific protection areas. Our States will be may be faced with such questions as:

o On what basis should we protect? Some may wish to establish a protection area based on current pumping conditions. But local officials may have picked locations for future wells. Should the protection areas for these wells be established and protection measures taken years before the wells are installed?

o Which modeling results should be used? At times, more than one protection area may be calculated for a given well despite the use of similar data. One area may reflect the conclusions of the computer modeling efforts of one group of experts; another area may represent the conclusions of another group. Since local officials may control certain land uses in the wellhead area, the difference will be significant for those who live in the zone between the two.

o Finally, if protection areas become larger in the future, what can be done about potential contaminating sources which are already present, such as industries, airports, and sewage treatment plants? What types of technical studies can, with available funds, and in the appropriate time period, assist in these decisions?

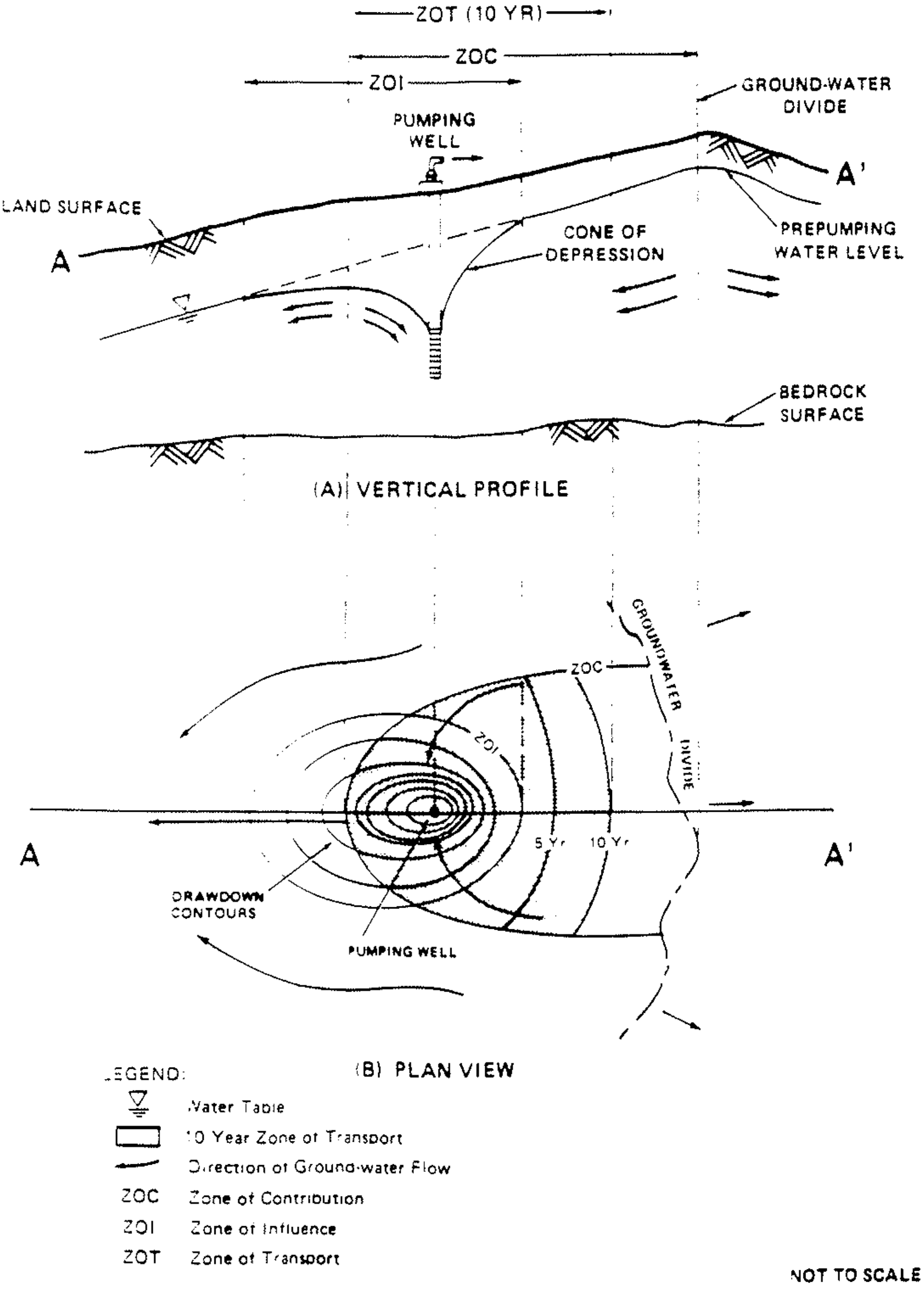
The protection of drinking water supplies for our citizens is an issue which crosses national boundaries. It is also one which demands the best of both applied and theoretical science. The Wellhead Protection Program is a cornerstone in this task.

## ACKNOWLEDGEMENTS

The author wishes to thank the Office of Ground-Water Protection for supporting this review. The conclusions and opinions expressed, however, are strictly those of the author, and should not be construed as representing official conclusions or policies of the U. S. Environmental Protection Agency.

Figure 1

Terminology for Wellhead Protection Area Delineation



# Aquifer Protection in Europe

C.R. Aldwell, Geological Survey of Ireland.

The continent of Europe extends from the Atlantic to the Urals and from the Arctic to a few tens of kilometres from the coast of Africa. Within this area there are great differences in the availability of water resources and thus the recognised importance attached to them.

Annual rainfall ranges from some 300mm in Malta to as much as 5 metres in the highest parts of some mountainous areas such as the Dinaric Alps in Yugoslavia. Other important physical factors for example temperature, topography and rock type also vary greatly.

Then there are variations in water demand affected by population density and the requirements of agriculture and industry and the impacts of all of these on the quality of surface and groundwater.

European countries with inadequate or barely adequate water resources within their borders include Cyrus, Gibraltar, Luxembourg, Malta, Portugal and Roumania together with considerable regions of Germany, Greece, Italy and Spain.

Those with abundant surplus resources are a shorter list including Iceland, Ireland, Norway and Scotland.

These many variations affect strongly the thinking and practical approach of different peoples towards the value of water resources and the importance attached to their protection.

The role and importance of groundwater in water supply also varies considerably. In general however, it is 70% or greater. Drinking water is even more reliant on groundwater, indeed in most of Europe today groundwater and drinking water are synonymous terms. In southern Europe and Denmark this is due mainly to lack of permanent rivers and in much of central and northern Europe because of the serious pollution of most of the main rivers.

The evolution of legislation, regulations and measures to protect groundwater in Europe has been stimulated by the nature of the perceived treats to water supplies. Europeans having degraded their surface water turned to the apparently safer groundwater only to find it in turn to be under threat.

widely practised in these countries and has spread with various modifications to their neighbours. It has worked well for them, even if some doubts have been raised as to the actual security provided by periods of 50 or even 100 days in the case of some viruses and persistent chemicals.

It is to be stressed that the geology of this type enables such an approach to operate and at the same time to meet the practical requirements for a protection zone being "as large as necessary and as small as possible" (van Waegeningh, 1985).

## Fissured Aquifers

These are consolidated aquifers in which water occurs in cracks or fissures in the rock. A number of factors made it necessary to approach groundwater protection in a different way from the porous aquifers. The most important differences are:

1. relatively rapid rate of groundwater movement;

2. the fissure systems frequently are irregular in form and sometimes more or less haphazard in their direction and extent.

3. as a consequence of their complexity, the necessary detailed information to provide a reliable model usually is lacking.

4. the rate of movement limits the opportunity for attenuation and the elimination of microbes. (Skinner, 1985).

Clearly protection zones in such conditions must be much larger than in porous aquifers. The hydogeologist faced with such conditions understandably will tend to play safe and define the areas conservatively. That quickly introduces conflict with economic interests and general questioning as to the justification for such protective measures.

Fissured aquifers occur widely in most European countries and are of considerable importance in many, including the UK and Ireland.

The Germans with a long tradition of protection zones and culturally and legally geared to methods of strong regulation operate a 2km radius zone for fissured aquifer sources (van Waegeningh 1985). Others feel such a rigid approach is unjustifiable and overkill.

from adjoining non-karstic areas may be possible. Karstic aquifers are the sole source of fresh water in much of the Mediterranean region. Indeed the famous limestone terrains of Yugoslavia cover an area greater than the whole of Ireland.

At the end of 1990 a European research project on "the hydogeological aspects of groundwater protection in karstic areas" began within the COST programme. (European Cooperation in the field of Scientific and Technical Research). The general objectives include:-

1. the delineation of protection zones in karstic terrains;

2. the definition of karstic drainage areas and their related water dynamics;

3. the evaluation of groundwater resources in karstic areas;

4. the optional use of groundwater in karstic terrains.

It is led by Yugoslavia, and Ireland proposes to take an active part.

In overall terms then, in Europe the methods of aquifer protection range from those that are based on certain formulae and assumptions of a general nature to systems that rely mainly on professional interpretation of the specific needs of an aquifer and are designed accordingly.

Table 1 attempts to indicate the position in eleven European countries.

It may be informative to look in a little more detail at the present position of groundwater protection in three contrasting European countries, Denmark in the north, Czechoslovakia in the centre and Italy in the south.

## DENMARK

Area 43,000km$^2$. Population 5.1 million

Groundwater as percentage of natural water supply 98%
Estimated percentage of available groundwater resources used 40%
Summary of geology. Extensive and often thick Quaternary deposits overlying Tertiary and Cretaceous sediments.
Main Aquifers. Quaternary sand and gravel, Tertiary sandstones and limestones, Cretaceous chalk. (E.C. 1982).

- amendments 1986, 1987.

* Waste Disposal Site Act, Act No. 420 of 13th June 1990.

* Statutory Orders
  - No. 2 of 4th January 1980 concerning water resources and water supply planning - amendment 1983.
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  - No. 4 of 4th January 1980 concerning well drilling for groundwater.
  - No. 469 of 11th July 1986 concerning imposition of contributions to distribution pipes and service pipes according to section 53 of the Water Supply Act.
  - No. 470 of 11th July 1986 concerning expropriation for water supply systems.
  - No. 515 of 29th August 1988 concerning water quality and supervision of water supply systems.

## ITALY

Area 301,000km$^2$ Population 57 million

Groundwater as percentage of national water supply 93%

Main Aquifers

Quaternary sands and gravels

Tertiary sandstones, limestones and dolomites

Tertiary - recent volcanics

Cambrian dolomites (E.C. 1982)

Main Groundwater Protection Issues in Italy

Serious reduction in autumn/winter rains due to blocking anticyclones leading to deterioration in groundwater quality;

Overpumping, especially in the Po plain, leading to induced recharge of polluted water into the aquifers and saline intrusions in coastal areas;

Pollution from industry and urbanisation e.g. c 50% of groundwater in the Milan area is polluted by chlorinated solvents;

Pollution from intensive agriculture including pesticides, fertilizers and wastes.

1975 Second SWMP introduced. More comprehensive than the first one. An important item concerned the long-term protection of groundwater quality.

Czechoslovak law recognises three types of water:

surface water
groundwater
special waters (ie mineral waters).

Groundwater has a priority usage as drinking water. Legally it is assumed that all groundwater is or will be tapped for drinking water and therefore must be protected. The law provides for two types of groundwater protection - general protection and specific protection of public supplies.

The groundwater supply sources receive specific protection by three levels of protection zones.

Zone 1 First degree protection of immediate vicinity of well. Extent is several tens of $m^2$. All activities are excluded.

Zone 2 50 day travel time. Second degree protection usually extends over several hundred $m^2$ to a few $km^2$. They are designed to exclude potential polluting activities of a microbial nature.

Zone 3 10 years travel time. This zone is aimed to protect against persistent chemicals. The restrictive measures are quite limited.

The general protection of groundwater resources requires some restrictions over the recharge areas of important aquifers. These areas cover several hundreds of $km^2$.

<u>Groundwater Protection Legislation in Czechoslovakia</u>

1973 Water Law. Federal Act no. 138/1973.

Since the revolution in 1989 a Ministry of the Environment set up. An updating of the 1973 law currently is in preparation.

<u>Groundwater Protection Issues in Czechoslovakia</u>

Increasing levels of nitrogen from non-point agricultural sources.

Failure by many collective farms and industries to observe the law either through carelessness and/or ignorance.

Lack of adequate supervision of the use of agricultural chemicals.

Table I: Tentative comparison of protection areas.

| Prohibitions | Fed. Rep. Germany | Austria | Belgium | Finland | The Netherlands | France | Switzerland | Csechoslovakia | Hungary | Sweden | Great Britain |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Only Water supply activities allowed | Zone I<br>Well field<br>10 m | Immediate Protection area | Immediate Protection zone | Intake area<br>???? | Well field | Immediate protection<br>(10 à 20 m) | zone I<br>10 — 20 m | First sanitary production zone<br>10 — 50 m | Protection zone | Well area | immediate non-statuatory protection area (normally 10-50 m) |
| Prohibition on building<br>Agricultural restrictions | Zone II<br>50 days | Protection area<br>50 days | 100 m<br>24 hrs.<br>Inner protection area<br>(300-1000 m)<br>50 days | Inner protection zone<br>60 days | Catchment area<br>(≥ 30 m)<br>50 à 60 days) | Inner protection area<br>???? | zone II<br>10 days<br>≥ 100 m | Internal second sanitary protection zone<br>???? | 50 days ??? | Inner protection area<br>≥ 60 days<br>≥ 100 m | no fixed zones but groundwater protection achieved through consultation under statuatory development planning and environmental control procedures with priority to aquifer recharge areas (Vulnerability classifications may be used as tools in this process) |
| Restrictions on certain industries, storage and transport of certain chemicals and oil | Zone III A<br>2 km | Partial protection area | Remote protection area | Outer protection zone | Protection area<br>10 years delay<br>Protection area<br>25 years delay | Remote protection area | zone III<br>≥ 200 m<br>zone A | External second sanitary protection zone | hydro geological protection area<br>25-100 year delay | Outer protection area | |
| | Zone III B | | | | Far recharge area | | zone B | | regional protection | | |

OUTER BOUNDARY OF RECHARGE AREA

(van Waegeningh, 1985).

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The evolution of legislation, regulations and measures to protect groundwater in Europe has been stimulated by the nature of the perceived treats to water supplies. Europeans having degraded their surface water turned to the apparently safer groundwater only to find it in turn to be under threat.

The two main threats to groundwater come from

1. degradation derived from the addition of the whole gamut of pollutants arising from the type and form of modern human activity and way of life;

2. overpumping causing quality changes by drawing in lower quality water or even sea water.

Not surprisingly all European countries have been examining, especially in the last few decades, the question of how to protect groundwater by providing the necessary legislative basis.

Some countries have attempted to do so by means of general water acts or more recently general water protection acts. Countries more or less following this route include Austria, Finland, Germany, Ireland, Italy, Poland, Spain, Sweden and the U.K.

In other countries matters relating to groundwater protection are scattered in a wide range of acts and regulations. Such countries include Belgium, Cyprus, Denmark, France, Greece, Luxembourg and Roumania, (FAO, 1964).

When it comes to the specifics of groundwater protection measures, an important determining factor is the nature of a country's main aquifers.

From a groundwater protection point of view aquifers can be classified in three main groups:

1. porous permeable

2. fissured

3. karstic

## Porous Permeable Aquifers

In these aquifers the sediments are unconsolidated or loosely consolidated. Where they are extensive, groundwater movement often is slow so that during 50 days water may only move a distance of 30-500m. Such a situation provides a die off time for most bacteria, an opportunity for attenuation or degrading of some chemicals as wells as a reasonable period for an early warning of coming pollution in the event of an accident.

Such conditions exist in much of Denmark, northern Germany and the Netherlands. This explains their approach to groundwater protection, based on protection zones, which is widely practised in these countries and has spread with various modifications to their neighbours. It has worked well for them, even if some doubts have been raised as to the actual security provided by periods of 50 or even 100 days in the case of some viruses and persistent chemicals.

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The Germans with a long tradition of protection zones and culturally and legally geared to methods of strong regulation operate a 2km radius zone for fissured aquifer sources (van Waegeningh 1985). Others feel such a rigid approach is unjustifiable and overkill.

Discussion and experimentation to find methods to enable more appropriate measures which maximise groundwater protection on a flexible basis has been taking place in a number of European countries such as Czechoslovakia, France, Switzerland and the UK.

These approaches attempt to include limited protection zoning in conjunction with vulnerability assessment using all available data. The aim is to come up with individual tailoring of protection for these more complex and vulnerable types of aquifers.

## Karstic Aquifers

The third main group of aquifers occurring widely in Europe are those in easily soluble limestones referred to generically as karstic. These aquifers have conduit flow. Karstic aquifers represent an extreme form of fissuring with flow rates of as much as 27 km/day. The karstic systems are in many ways underground streams and rivers with most of the risks of surface water. They have the added hazard that they are out of sight and many people may regard their reemerging springs or wells sunk in them as automatically safe.

The specific problems facing groundwater protection in karstic regions are summarised succinctly by the Swiss Hydrogeologist, Rene Blau based on the 1978 IAH meeting in Basel "Drinking-water protection for groundwater":

1. Insufficient purification of water underground;

2. rapid flow;

3. pollutants travel long distances;

4. very large protection areas needed (may be whole catchment);

5. the scale of measures needed to provide full protection is out of proportion to the benefits;

6. Doubts on feasibility of successful implementation.

He suggests that solutions to these problems range between no special protection for wells and springs and, severe limitation of land-use throughout the catchment area.

He considers the appropriate balance must include some preventive measures in the whole catchment but this must be tempered by allowing limited risks. The absence of such a qualification could lead to karstic regions becoming no longer economically viable and end up uninhabited (Blau, 1981). In some countries the solution of piping in water from adjoining non-karstic areas may be possible. Karstic aquifers are the sole source of fresh water in much of the Mediterranean region. Indeed the famous limestone terrains of Yugoslavia cover an area greater than the whole of Ireland.

At the end of 1990 a European research project on "the hydogeological aspects of groundwater protection in karstic areas" began within the COST programme. (European Cooperation in the field of Scientific and Technical Research). The general objectives include:-

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Main Groundwater Protection Issues in Denmark

Ecological balance for each farm;

Target reduction of emissions of nitrogen to 50% of present and phosphorous to 80% of present levels;

Control of agricultural wastes;

Location of landfill sites only in districts without public water abstractions;

Identification of and sanitization of old waste sites;

Restrictions on extraction of raw materials;

Preservations of wetlands.

Groundwater Protection Measures in Denmark

1920-1949 First act to regulate water supply 1926. Adhoc Water Commissions set up: licences to abstract groundwater other than domestic: Protection zones introduced: Data required to be sent to Danish Geological Survey from 1926;

1950s Water Balance Committee set up to guard against pollution and over abstraction;

1960s National Hydrological Committees set up;

1970 Land-use planning and environmental protection decentralised to new regional districts;

1973 Environmental Protection Act;

1974 Water Supply Act;

1983 Water Council Set up by Minister for the Environment;

1990 Water Environmental Scheme introduced with aim to ensure ongoing quality of groundwater. Estimated cost 12 billion DCRs (about IR£1 billion).

Groundwater Protection Legislation in Denmark (as of 1st January, 1990).

* The Water Supply Act, No. 299 of 8th June 1978
  - amendments 1982, 1984, 1985, 1987, 1988, 1988.

* The Environmental Protection Act, Act No. 85 of 8th March 1985, part 3 Protection of Groundwater and Water Supply Interests

- amendments 1986, 1987.

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Quaternary sands and gravels

Tertiary sandstones, limestones and dolomites

Tertiary - recent volcanics

Cambrian dolomites (E.C. 1982)

Main Groundwater Protection Issues in Italy

Serious reduction in autumn/winter rains due to blocking anticyclones leading to deterioration in groundwater quality;

Overpumping, especially in the Po plain, leading to induced recharge of polluted water into the aquifers and saline intrusions in coastal areas;

Pollution from industry and urbanisation e.g. c 50% of groundwater in the Milan area is polluted by chlorinated solvents;

Pollution from intensive agriculture including pesticides, fertilizers and wastes.

Groundwater Protection Measures in Italy

1976 Act no. 319 sets out rules for protection of groundwater against pollution.

1985 Regulation on drinking water quality.

1988 Act no. 386. This acts meets the requirements of EC directive 80/778. It introduces national guide and permissible limits and introduces water protection areas. It also provides for wide ranging technical regulation.

Late in 1988 the Minister for the Environment set up a Commission of experts to establish how the technical regulation should take place. Its wide ranging terms of reference included, land-use regulation, vulnerability mapping, centralised analysis and disaster plans. (Civita, 1991.)

## CZECHOSLOVAKIA

Area 128,000km$^2$ Population 16.2 million

Summary of Geology The two major geological components are the Bohemian Massif composed essentially of assorted metamorphic rocks and in Slovakia the Carpathian mountains of Alpine age made up of a complicated series of Palaeozoic and Mesozoic rocks. Extensive and deep Tertiary basins flank these major units. The main Czech Cretaceous basin covers much of northern Bohemia and Moravia.

Main Aquifers

CZECH REPUBLIC

Czech Cretaceous Basin (15000km$^2$). V. good quality

Alluvial aquifers along rivers Labe (Elbe) and Vlatava (Moldau) - often polluted

SLOVAK REPUBLIC

Karstic aquifers in west, central and eastern Slovakia;

Alluvial aquifers along the river Danube.

Some pollution in both groups of aquifers.

Water Protection in Czechoslovakia

1954 State Water Management Plan mainly concerned with quantitative aspects of water resources.

1975 Second SWMP introduced. More comprehensive than the first one. An important item concerned the long-term protection of groundwater quality.

Czechoslovak law recognises three types of water:

surface water
groundwater
special waters (ie mineral waters).

Groundwater has a priority usage as drinking water. Legally it is assumed that all groundwater is or will be tapped for drinking water and therefore must be protected. The law provides for two types of groundwater protection - general protection and specific protection of public supplies.

The groundwater supply sources receive specific protection by three levels of protection zones.

Zone 1 First degree protection of immediate vicinity of well. Extent is several tens of $m^2$. All activities are excluded.

Zone 2 50 day travel time. Second degree protection usually extends over several hundred $m^2$ to a few $km^2$. They are designed to exclude potential polluting activities of a microbial nature.

Zone 3 10 years travel time. This zone is aimed to protect against persistent chemicals. The restrictive measures are quite limited.

The general protection of groundwater resources requires some restrictions over the recharge areas of important aquifers. These areas cover several hundreds of $km^2$.

Groundwater Protection Legislation in Czechoslovakia

1973 Water Law. Federal Act no. 138/1973.

Since the revolution in 1989 a Ministry of the Environment set up. An updating of the 1973 law currently is in preparation.

Groundwater Protection Issues in Czechoslovakia

Increasing levels of nitrogen from non-point agricultural sources.

Failure by many collective farms and industries to observe the law either through carelessness and/or ignorance.

Lack of adequate supervision of the use of agricultural chemicals.

Spillage and leakage of oil and chlorinated hydrocarbons.

Clean up relating to Soviet military bases, now being closed.

(Main data supplied by J. Vrba, pers comm.)

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Table I: Tentative comparison of protection areas.

| Prohibitions | Fed. Rep. Germany | Austria | Belgium | Finland | The Netherlands | France | Switzerland | Csechoslovakia | Hungary | Sweden | Great Britain |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Only Water supply activities allowed | Zone I<br>Well field<br>10 m | Immediate Protection area | Immediate Protection zone | Intake area<br>? ? ? ? | Well field | Immediate protection<br>(10 à 20 m) | zone I<br>10 — 20 m | First sanitary production zone<br>10 — 50 m | Protection zone | Well area | Immediate non-statutory protection area (normally 10-50 m) |
| Prohibition on building Agricultural restrictions | Zone II<br>50 days | Protection area<br>50 days | 100 m<br>24 hrs.<br>Inner protection area<br>(300-1000 m)<br>50 days | Inner protection zone<br>60 days | Catchment area<br>(> 30 m)<br>50 à 60 days) | Inner protection area<br>? ? ? ? | zone II<br>10 days<br>≥ 100 m | Internal second sanitary protection zone<br>? ? ? ? | 50 days ??? | Inner protection area<br>≥ 60 days<br>≥ 100 m | no fixed zones but groundwater protection achieved through consultation under statuatory development planning and environmental control procedures with priority to aquifer recharge areas (Vulnerability classifications may be used as tools in this process) |
| Restrictions on certain industries, storage and transport of certain chemicals and oil | Zone III A<br>2 km | Partial protection area | Remote protection area | Outer protection zone | Protection area 10 years delay<br>Protection area<br>25 years delay | Remote protection area | zone III<br>≥ 200 m<br>zone A | External second sanitary protection zone | hydro geological protection area<br>25-100 year delay | Outer protection area | |
| | Zone III B | | | | Far recharge area | | zone B | | regional protection | | |

OUTER BOUNDARY OF RECHARGE AREA

(van Waegeningh, 1985).

# GROUNDWATER PROTECTION IN IRELAND

Donal Daly
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## INTRODUCTION

The approach taken to the protection of groundwater in Ireland is influenced by several factors:

1. The geology and hydrogeology of the country are complex. The most important aquifer - limestone - has a secondary or fissure permeability only and is often karstified and so is very unpredictable. Similarly the other main bedrock aquifers - sandstones and volcanics - also have a fissure permeability. The unconsolidated Quaternary deposits - sands, gravels, tills and clays - which overlie the bedrock aquifers are very variable in thickness, extent and lithology, reflecting their chaotic mode of deposition during the Ice Age.

2. Diffuse pollution sources such as fertilizers are not yet causing pollution problems and are unlikely to cause the same degree of problem in Ireland as in many European countries.

3. The main threat to groundwater is posed by point sources - farmyard wastes (silage effluent and soiled water mainly), septic tank effluent, sinking streams and to a lesser extent leachate from waste disposal facilities, leakages and spillages.

4. Detailed geological and hydrogeological knowledge is lacking for many areas in Ireland.

5. The number of people with specialised training in groundwater working in Ireland is small - a total of three hydrogeologists in the public sector and a small number of consultants in the private sector. Responsibility for water supply and protection from pollution rests mainly with engineers and planners who have limited training in the groundwater area.

6. Pollution of wells and springs is occurring and the risks of pollution are increasing.

7. Due to budgetary constraints, there are unlikely to be significant extra financial resources made available in the foreseeable future for research on groundwater development and protection.

8. Groundwater pollution risk depends on the interaction between
   a) the natural vulnerability of the aquifer, and
   b) the pollution loading that is, or will be applied to the sub-surface environment.

   Vulnerability is an intrinsic characteristic of an aquifer whereas pollution loading can be controlled or modified.

In view of these factors the Geological Survey of Ireland is recommending a pragmatic approach to groundwater protection using available information and expertise without requiring extra detailed and expensive investigations.

The approach involves several stages:

1. Preparation of an <u>initial</u> groundwater protection scheme;

2. Vulnerability assessments using water quality data and readily available geological and hydrogeological data;

3. Assessments of groundwater pollution loading;

4. Site investigations; and

5. Preparation of a <u>final</u> groundwater protection scheme.

## STAGE 1: PREPARATION OF AN INITIAL GROUNDWATER PROTECTION SCHEME

The scheme consists of two components: a groundwater protection map and a code of practice.

### Groundwater Protection Map

The map is based on the division of any area, such as a local authority area, into 4 groundwater protection zones (analagous to planning zones) according to the degree of protection required, Zone 1 requiring the highest degree of protection and Zone 4 the least.

**Zone 1:** Source protection zone around each designated groundwater supply source (public and group scheme supplies and important industrial supplies). It is subdivided into three subzones; 1A, 1B and 1C.
Zone 1A is the area within 10m from the source,
Zone 1B is the area between radii 10-300m, and
Zone 1C is the area between radii 300-1000m.
If there is sufficient geological or hydrogeological information available at this stage the distances can be varied to suit the hydrogeological conditions in any area. Also they can be modified and improved as more up-to-date geological and hydrogeological information becomes available.

**Zone 2:** Major aquifers

**Zone 3:** Minor aquifers

**Zone 4:** Poor and non-aquifers

These zones are shown on a map at 1:100,000 scale or 1:50,000 scale.

### Code of Practice

A code of practice is then prepared which lists the generally acceptable and unacceptable activities for each zone and describes the recommended controls for potentially polluting developments. This can be varied to suit the needs of the local authority. An example of a code of practice is given below.

<u>Zone 1A:</u> It should be fenced in and all activities which have any potential to pollute should be forbidden.

Zone 1B: The following developments would normally be prohibited:

i) septic tanks treatment systems;
ii) the spreading of slurry, manure and sewage sludge;
iii) the establishment of burial grounds;
iv) waste disposal sites;
v) any industrial development which would involve the use, production, and storage of toxic or potentially polluting material;
vi) intensive agricultural activities such as intensive rearing or housing of livestock and the construction of silage pits;
vii) the construction of main foul sewers;
viii) the construction of sewage and trade effluent treatment works;
ix) the excavation of minerals extending below the water table.

Zone 1C: All the developments listed for Zone 1B, with the exception of (1), (2) and (3), should not generally be allowed.

Zone 2: Activities which should normally be prohibited include

i) waste disposal sites intended to receive hazardous or toxic wastes, including domestic wastes, industrial and chemical wastes and sewage sludge;
ii) major industrial and agricultural developments (such as piggeries) which involve the use, storage or handling of potentially polluting materials, unless adequate protective measures are agreed with the local authority.

Zone 3: Although potentially polluting developments are discouraged, a balancing of interests between the need to protect groundwater resources and the need to locate potentially polluting developments may often be necessary.
Waste disposal sites and major industrial and agricultural developments are discouraged and are only allowable if adequate precautions are taken and the risks are reduced to an acceptable level.

Zone 4: No objections to any activities except when an existing groundwater source is being put at risk.

At present there is sufficient hydrogeological information available to enable this first stage - the preparation of an initial groundwater protection scheme - to be drawn up. The Geological Survey of Ireland is recommending that the local authorities should prepare these basic schemes in order to give some protection to groundwater in the short and medium term. Several local authorities have already done so - Offaly, Wexford, north Cork, Mayo and Louth. However it is emphasised that these schemes have no statutory authority. They are intended as a guide for decision-makers - engineers and planners mainly - in considering developments which have the potential to pollute groundwater.

## STAGE 2: VULNERABILITY ASSESSMENTS

Two main approaches to vulnerability assessments are adopted:

a) vulnerability mapping using geological and hydrogeological data; and
b) using water quality data.

## Vulnerability Mapping

The vulnerability of groundwater to pollution varies greatly depending on a number of inter-related geological and hydrogeological factors:

a) Type (lithology) of subsoil (unconsolidated, largely Quaternary deposits);
b) Permeability of subsoil;
c) Thickness of subsoil over bedrock;
d) Type of permeability - intergranular or fissure;
e) Thickness of unsaturated zone;
f) Attenuating capacity of subsoil and bedrock; and
g) Type of recharge - whether diffuse or by sinking streams.

**Vulnerability mapping is the technique of assessing all the geological and hydrogeological factors and ranking the vulnerability of groundwater and displaying it on a map in a manner which is understandable and useful.**

Vulnerability maps can be prepared using existing geological, depth to bedrock and hydrogeological data and preferably supported by short reconnaissance surveys. Hydrogeological expertise is essential in preparing these maps.

Limited staffing or financial resources may restrict the vulnerability mapping to the areas covered by Zone 1 and Zone 2, but if possible the total area should be assessed.

Figure 1 illustrates a basic vulnerability map in the vicinity of a spring in central Ireland together with maps showing the geological and hydrogeological information. These maps, which were compiled at 1:25,000 scale, are based on existing data on Geological Survey files, examination of aerial photographs, discussions with local authority staff and a three-day reconnaissance survey by a Quaternary geologist. A detailed discussion of the vulnerability assessment will not be given in this paper. However, it is worth noting how a brief assessment of the probable recharge area of this spring draws attention to significant aspects such as the presence of relatively high permeability sandy till over much of the area, the shallow till in the vicinity of the intermittent stream and the karst features - sink holes, scarcity of surface streams, intermittent streams, possible collapse features and turloughs (seasonal lakes).

## Vulnerability Assessment Using Water Quality Data

The vulnerability of wells and springs can be placed within decreasing pollution risk categories based on either existing or readily obtainable groundwater quality data. Hardness (in limestone areas), conductivity, temperature and bacteriological data are usually appropriate parameters. The variations in hardness and/or conductivity levels in response to recharge between groundwater sources can enable comparison of the degree of vulnerability to pollution. It is reasonable to assume that the more rapid the response to recharge and the greater the variations the more vulnerable the source is to pollution. Regular measurements - fortnightly is usually considered adequate in Ireland - are needed for this technique. Wells or springs can also be placed within decreasing pollution risk categories based on whether bacterial pollution is regular, occasional or absent.

This type of assessment can enable engineers in local government bodies to give priority to the more vulnerable sources when preparing protection policies.

## Vulnerability Rating and Hydrogeological Setting

Vulnerability ratings for different typical Irish hydrogeological settings are given in Table 1. These ratings are subjective and qualitative. This is inevitable as geological and hydrogeological knowledge will normally be inadequate to enable quantitative and impartial ratings to be determined. However, provided the limitations are appreciated, vulnerability assessments can be a powerful tool in protecting groundwater.

**Table 1**

| Vulnerability Rating | Hydrogeological Setting |
|---|---|
| **Extreme:** | 1. Outcropping bedrock aquifers (particularly karst limestone) or where overlain by shallow (less than 3m*) subsoil.<br>2. Sand and gravel aquifers with a shallow (less than 3m*) unsaturated zone.<br>3. Areas near karst features such as sink holes. |
| **High:** | 1. Bedrock - major, minor and poor aquifers and non-aquifers - overlain by 3m+ sand and gravel or 3-10m sandy till or 3-5m low permeability clayey tills or clays.<br>2. Unconfined sand and gravel aquifers with 3m+ unsaturated zone. |
| **Moderate:** | 1. Bedrock - major, minor and poor aquifers and non-aquifers - overlain by 10m+ sandy till or 5-10m clayey till, clay or peat.<br>2. Sand and gravel aquifers overlain by 10m+ sandy till or 5-10m clayey till, clay or peat. |
| **Low:** | 1. Confined bedrock aquifers overlain by 10m+ clayey till or clay or low permeability bedrock such as shales.<br>2. Non-aquifers and poor aquifers overlain by 10m+ clayey till or clay.<br>3. Confined gravel aquifers overlain by 10m + clayey till or clay. |

* Note: In theory less than 1m subsoil or unsaturated zone beneath a development rather than 3m should be the cut-off depth for the "extreme" rating., However, taking a thickness of 3m rather than 1m is regarded as more practical and useful for the following reasons:
(a) the base of many developments - septic tank systems or farmyard effluent holding tanks for instance - are 1-3m b.g.l.;
(b) in preparing a vulnerability map the general rather than the site specific situation must be taken into account; and
(c) a 3m cut-off depth allows for lateral variations and often provides a safety margin. Obviously if the base of a potentially polluting development is more than 3m deep, the rating classification may be affected.

## STAGE 3: ASSESSMENT OF GROUNDWATER POLLUTION LOADING

Vulnerability assessments of any area by themselves do not provide a system of groundwater protection. They have to be linked to surveys and assessments of existing potentially polluting activities, and a code of practice for locating and regulating existing and new developments.

One method of taking account of the pollution loading is to survey the existing potentially polluting sources and to overlay the vulnerability map with a map showing the locations of these sources. An assessment of pollution risk is then possible. Also local government staff can give priority to monitoring the developments placing groundwater at most risk.

In many areas in Ireland the local government authorities have already carried out farm surveys which have located and quantified farm waste sources. These surveys could readily be expanded to include other potentially polluting sources such as septic tank systems and industrial developments.

## STAGE 4: SITE INVESTIGATIONS

The information provided by stages 2 and 3 enable an assessment of the existing geological and hydrogeological data and of the pollution risks to groundwater. Depending on this assessment and on the available financial resources, site investigations may be carried out.

## STAGE 5: PREPARATION OF FINAL GROUNDWATER PROTECTION SCHEME

The final stage is to refine the code of practice and the zonal boundaries prepared in stage 1 based on the information collected in stages 2, 3 and 4. The final product is a map showing four zones - source protection zones (Zone 1), major aquifers (Zone 2), minor aquifer (Zone 3) and poor or non-aquifers (Zone 4) -, subdivided on the basis of groundwater vulnerability to pollution. The map scale should preferably be 1:50,000 although 1:100,000 is adequate. Large scale vulnerability maps - 1:25,000 or 1:10,000 - are recommended for the source protection zones. The maps include warnings that they have no statutory authority and should not be used alone to determine site-specific susceptibility of groundwater to pollution from specific sources.

The scheme must be integrated into the planning process.

## USE OF GROUNDWATER PROTECTION SCHEMES AND VULNERABILITY ASSESSMENTS

A well prepared groundwater protection scheme has the following benefits and uses:

1. It brings the groundwater interest to the attention of decision-makers and makes information widely available.

2. It assists planners and engineers in locating and regulating potentially polluting activities:
   - by contributing to the search for a balance of interests between water protection issues and other special and economic factors;
   - by assisting in the preparation of development, water quality and waste management plans;

- by setting priorities for technical resources, as they provide a hierarchy of levels of concern;
- by acting as a guide for local government staff and providing a "first-off" warning system which can be used before site visits or investigations are made;
- by controlling developments and encouraging them in areas of least concern, it helps to ensure that the pollution acts are not contravened.

3. It assists local authorities bodies in making water treatment investment decisions.

4. It enables more detailed and expensive investigations to be directed where the threat is greatest.

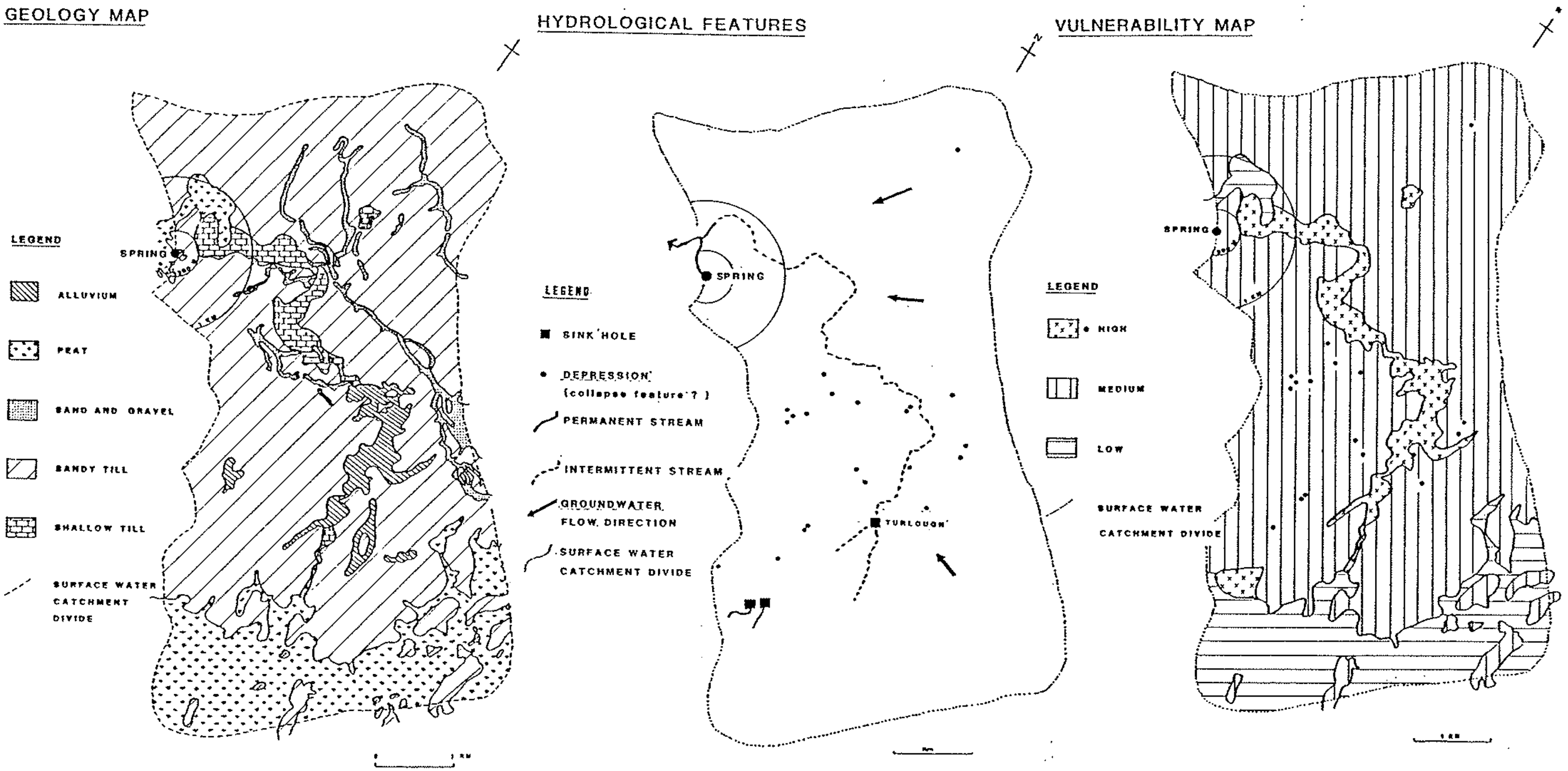
5. It enables industrial users to assess the pollution risk either before or after developing a groundwater source.

However, protection schemes are not a panacea for solving all problems. No scheme can provide absolute protection. It is particulary important that the limitations of vulnerability maps are clearly understood by those using them. For this reason a prominently displayed warning should be printed on the maps stating they are not to be used for specific siting purposes. It is moreover very desirable that if the maps are being used for decision making that a hydrogeologist be consulted in their interpretation. By their nature vulnerability maps generalise what in fact are often very variable geological conditions. They should be regarded as a guide which when used together with specific site investigations are a valuable step forward in the protection of groundwater. In practice their use needs a realistic and flexible approach.

It is considered that the advantages of protection schemes considerably outweigh the disadvantages because, by identifying options, they provide a positive contribution to multiobjective planning in a multifunctional organisation such as a local authority.

## CONCLUSION

The approach outlined in this chapter enables regulatory authorities to take account of groundwater when locating potentially polluting developments in situations where expensive site investigations and environmental impact assessments are not practicable or possible. It is a pragmatic approach that enables groundwater to be taken into account in balancing the various interests in land-use planning.




(These maps are reduced copies of the original 1:25,000 scale maps).

FIGURE 1. GEOLOGY, HYDROGEOLOGICAL FEATURES AND VULNERABILITY MAPS FOR SPRING CATCHMENT AREA.

Extract of paper presented to Institute of Engineers of Ireland

Presented by Gerry Fōrde to 11th Annual IAH Groundwater Seminar, Portlaoise, 9th and 10th April.

# AN AQUIFER PROTECTION POLICY FOR COUNTY WEXFORD

By

Thomas E. Hore, B.E., Dip. Comp. Eng., C. Eng., MIEI

In 1987 Wexford County Council's engineers and planning staff, with the help of consultant hydrogeologist Mr. Kevin Cullen, began detailed discussions on all aspects of development pertaining to groundwater, with a view to formulating an Aquifer Protection Policy specifically suited to County Wexford's unique position and the continuing vital importance of the groundwater resource to the development of the County in all spheres of activity. A paramount consideration was that the necessary development restrictions incorporated in the Aquifer Protection Policy should be perceived as being reasonable and serving the common good, to ensure that said restrictions would be more acceptable to the elected representatives and the general public.

Policy guidelines have now been prepared and it is proposed that this policy will be incorporated in the revision of the County Development Plan for the five year period beginning 1991, in order to provide statutory backing and strong control measures under the Planning Acts to enforce the proposed restrictions.

The aim of the proposed Aquifer Protection Policy is to maintain the present excellent quality of groundwater in County Wexford. The policy starts from a point where no level of potential groundwater pollution activity is acceptable and moves back from this position to achieve a realistic balance of community

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interests. By recognising all effluents as the principal cause of groundwater pollution, the policy changes the debate from the volume or otherwise of the groundwater to the proper control and disposal of domestic, agricultural and industrial wastes.

The main proposals of the Aquifer Protection Policy, in the draft format proposed for inclusion in the County Development Plan, are outlined hereunder:-

## COUNTY WEXFORD AQUIFER PROTECTION POLICY

The use of the groundwater as a major source of public water supply has been steadily increasing in County Wexford, and because of the excellent aquifers available, it is the Council's policy to continue to develop this resource in the future.

The Council recognises the importance and vulnerability of the natural ground water and surface water resources of the County and has introduced the aquifer protection policy to ensure the long term protection of these vital resources.

The policy is based on a system of priority source protection zones related to the location of the aquifers, catchment areas and abstraction points. The objective of the policy is to control development within the aquifer zones in such a way as to prevent pollution and contamination of water resources.

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The zones are listed in the table below, giving extent, status and type of development control required. This table should be read in conjunction with the map which shows existing ground water abstractions and source protection zones.

**ZONE 1 - Source Protection Zone:**

| | | |
|---|---|---|
| **Sub-Zone 1 (a)** | **EXTENT** | : 10m from public groundwater abstractions. |
| | **STATUS** | : Fixed |
| | **PROHIBIT** | : All activities with any degree of pollution risk. |
| **Sub-Zone 2 (b)** | **EXTENT** | : 100m. from public groundwater abstractions. |
| | **STATUS** | : Variable with geological conditions. |
| | **PROHIBIT** | : Septic tanks.<br>Soakways of any type.<br>Spreading of sewage sludges.<br>Burial grounds.<br>Waste disposal sites.<br>Storage of industrial chemicals.<br>Storage or disposal of farm chemicals.<br>Foul sewers or house drains. |
| | **CONTROL** | : Application of fertilizers.<br>Spreading of manure or slurry. |
| **Sub-Zone 1 (c)** | **EXTENT** | : 1Km. from public groundwater abstractions. |
| | **STATUS** | : Fixed. |
| | **CONTROL** | : Waste disposal sites.<br>Storage of industrial chemicals.<br>Intensive agricultural developments.<br>Construction of waste liquid ponds.<br>Septic tanks - one acre sites.<br>Construction of foul sewers.<br>Construction of soak pits.<br>Use of farm chemicals. |
| **Sub-Zone 1 (d)** | **EXTENT** | : 100m. from surface watercourses and areas vulnerable to groundwater pollution. |
| | **STATUS** | : Fixed. |

/...

Sub-Zone 1 (d) Contd/-

| | |
|---|---|
| **PROHIBIT** : | Septic tanks.<br>Soakways of any type.<br>Spreading of sewage sludges.<br>Burial grounds.<br>Waste disposal sites.<br>Storage of industrial chemicals.<br>Storage or disposal of farm chemicals.<br>Foul sewers or house drains. |
| **CONTROL** : | Septic tanks - one acre sites.<br>Construction of foul sewers.<br>Construction of soak pits.<br>Use of farm chemicals. |

**ZONE 2 - Major Aquifer Protection Zone:**

| | |
|---|---|
| **EXTENT** : | Area underlain by major aquifer. |
| **STATUS** : | Fixed. |
| **CONTROL** : | Waste disposal sites.<br>Storage of industrial and farm chemicals.<br>Construction of waste liquid ponds.<br>Intensive agricultural developments.<br>Construction of septic tanks: 0.4 ha. sites.<br>Use of farm chemicals. |

The aquifer zones shown on the map are dependant on groundwater resources from both major and minor geological aquifers which cover a wide area and it is also necessary that the County Council exercises control of development within these areas to the extent needed to ensure ground water protection. This will involve control and management of larger developments giving rise to risk of pollution problems. In these instances each case will be examined on its own merits, having regard to individual circumstances.

## Source Protection Zone

Under the proposed protection policy for County Wexford, the Source Protection Zone is divided into four sub-zones with potentially polluting activities either prohibited or controlled, depending on the nature of the activity and its location vis a vis the point of abstraction.

## Major Aquifer Protection Zone

This area extends from the boundary of the Source Protection Zone and covers all the remaining area underlain by the major aquifer. In this area there is no strict prohibition per se, but every potentially polluting activity is subject to examination and control.

It can be seen therefore that the aquifer as a whole will be protected by strict development control. In general, proposed effluent generating activities will require individual examination and in many instances, may need hydrogeological investigation to ascertain the suitability of any development in relation to the County Council's obligation to protect the aquifer. The scope of any hydrogeological investigation would depend on the nature and volume of the effluent, the underlying ground conditions and the location of the proposed development within the aquifer. Therefore, the most intensive investigations will be directed where the threat is greatest, or where conflicts of interest are most likely to occur.

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This Aquifer Protection Policy will be regarded by many as unduly restrictive and many landowners may feel that their land development potential has been diminished.

However, in order to protect valuable groundwater resources for future generations, it is absolutely necessary that these controls should be introduced. It is intended initially to limit these controls to the two major aquifers, (i.e., the Volcanic and the Limestone) and all existing abstraction points, rather than have blanket controls over the whole County, which, at this stage, might be unreasonable. In any event, in the areas outside the two major aquifers the development control process under the Planning Acts will enable the County Council to closely monitor developments which could injure other potential groundwater resources.

<u>Groundwater Protection - The Planners Viewpoint:</u>

The Local Government (Planning and Development) Act, 1963, gives a Planning Authority statutory authorisation to regulate and control development in the interests of the common good. Thus, any person wishing to carry out development must apply for and receive Planning Permission with or without conditions attached thereto.

The refusal of a planning application would attract compensation, unless the reasons for refusal included specific items such as traffic hazard, premature development or public health. The 1990

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Planning Act extended the reasons for refusal which negate compensation claims, the most relevant one to this paper being that a development may not cause water pollution. Eighty percent of Wexford County Council's planning applications are for single houses in rural locations, using septic tanks and percolation areas as the means of sewage treatment and disposal. It is estimated that there are now in excess of 15,000 septic tanks in the County and it is a matter of pure conjecture as to the efficiency and effectiveness of these treatment systems. Soakpits were acceptable until the mid 1970s but since then a properly designed septic tank and percolation area, in accordance with the I.I.R.S. recommendations S.R.6.1975, has been a prerequisite for planning approval. The revised guidelines on septic tank drainage systems are awaited with interest. The Planning Authority has broad policy statements to discourage ribbon development and to concentrate housing into villages and towns where services and sewage treatment can most easily be provided (SIC!). County Wexford has 85 villages but there is a reluctance by many to locate in these settlements. Agricultural development is another major potential source of pollution. The control of this area of activity is more effectively policed by utilising the wide ranging provisions of the Local Government (Water Pollution) Act, 1977 and Local Government (Water Pollution) (Amendment) Act, 1990, rather than the Planning Acts, because of the extent of the exempted development allowed in the agricultural area.

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The protection of groundwater sources under the Planning Acts is both a positive and negative function. The positive aspect is the imposition of stringent conditions to prevent pollution by any development. The negative aspect is the refusal of development in certain areas, though this need not be defeatist, as there is usually an alternative acceptable site available elsewhere.

The conservation and exploitation of natural resources is a constant struggle towards proper planning and development, but, when the common good is the end objective, the means for achieving it is by example and legislation. The incorporation of the proposed Aquifer Protection Policy in the Development Plan for County Wexford, will greatly assist in this regard with particular reference to groundwater resources.

The following Notification of Determination of Planning Application is short and to the point.

## Environmental Impact Assessment

It is interesting to note that the environmental aspects of large groundwater abstraction schemes work in both directions. Whereas the County Council on one hand must guard against pollution of the aquifer by, for example, implementing a Groundwater Protection Policy; they must also prove satisfactorily that the actual water abstraction and ancillary works will not impact adversely on the overall environment in relation to the physical realities of

# WEXFORD COUNTY COUNCIL

Local Government (Planning and Development) Acts, 1963 to 1983

NOTIFICATION OF DECISION ON PLANNING APPLICATION

The decision of Wexford County Council on the application described at Part 1 of this form is given at Part 2. Please read the notes on reverse of document.

Signed of behalf of Wexford County Council ..........................

Date: 21st September, 1990

**Part 1.** Particulars of Application

| Name and address of applicant: | Type of Application |
|---|---|
| Leslie Sinnott<br>Mayglass<br>Drinagh<br>COUNTY WEXFORD | Permission for erection of dwelling house at Busherstown, Ballycogley. |
| | Number in Planning Register: 90/1000 |
| | Date of Application: 2nd August, 1990 |

**Part 2.** Particulars in Decision

DECISION: Permission Refused

Conditions and Reasons therefore:

A. The proposed development would be prejudicial to Public Health because the proposed septic tank treatment system would be within 100 m. of a source of public ground water abstraction. The septic tank tank effluent would cause pollution and the contamination of the water resource.

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the scheme.

Under the provisions of the European Communities (Environmental Impact Assessment) Regulations, 1989 and more specifically Article 24, First Schedule Part II, Item 2(b) therein an Environmental Impact Statement (Study) is required for any scheme involving 'drilling for water supplies where the expected supply would exceed 1.1 m.g.d.'. It is noted that the required Study is just one constituent part of the Environmental Impact Assessment (E.I.A.) process. The three parts are as follows:-

(1) The Environmental Impact Study (E.I.S.).

(2) The Comments on the Public.

(3) The Assessment of the Competent Authority.

With regard to this scheme, the Competent Authority is the Minister for the Environment who will examine the E.I.S. and the comments of the Public before giving his decision as to whether the scheme can proceed.

Such a study, the first of its kind in Ireland, was prepared by P. H. McCarthy, Son and Partners, for the Fardystown Regional Water Supply Scheme, which as outlined previously, is expected to deliver some 5.8 m.g.d. from the limestone Aquifer by the year

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2005. The environmental impact of the scheme was investigated in relation to the following areas:-

a) Socio-Economic Impact.
b) Public Health Impact.
c) Visual Impact.
d) Climatic Impacts.
e) Impact of Residues.
f) Groundwater Impacts.
g) Archaeological, Cultural and Heritage Impacts.
h) Noise and Vibration Impacts.
i) Public Safety Impact.
j) Impact on Flora and Fauna.
k) Impact on Wild Birds.
l) Material Assets Impact.
m) Construction Impacts.

A summary of the groundwater impacts is outlined hereunder:-

From a groundwater viewpoint the abstraction of some 5.8 m.g.d. of groundwater will result in a drawdown of some 20 - 30m at the individual boreholes, reducing to 2 - 3m at 1km away. This regional groundwater level lowering will result in the landward movement of the saline / fresh water interface by 100 - 500m. Also, existing spring flows and river base flows will be reduced while the risk of induced sinkholes is increased. To minimise the risks posed by groundwater abstraction, borehole sites are chosen so as to spread the drawdown over as big an area as possible, thus limiting the magnitude of drawdown locally. Six observation boreholes are being sited to the South and East of the aquifer so that groundwater levels can be monitored. Where groundwater lowering results in the loss of existing private sources, the Council will provide alternative supply. The

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negative impacts of the proposed groundwater abstraction are considered to be minimal.

## Other Aspects of Pollution and Protection

***Saline Intrusion:***

1. In December, 1982, Wexford County Council received a Planning Application for a proposed limestone quarry at Jacketstown, situated within the limestone aquifer regime and almost equidistant from existing major County Council production boreholes along the Wexford / Rosslare Road and the sea. In fact, the land immediately between the proposed quarry location and the sea is reclaimed low lying land and consequently the site straddled the fresh water/salt water interface. The developers intended excavating down to between 15 m. (50 feet) and 18 m. (60 feet) below ground level and lowering the water table below this depth over the whole quarry area to maintain dry working conditions. It is worth noting in this respect that the ground surface is just above sea level and that the water table is within 1.5 m. of the ground level. The proposal to lower the water table by some 18 m. below sea level over such a wide area (3 acres) was considered by Wexford County Council, in light of expert advice, to have serious consequences as to the long term security of the fresh water aquifer on which the production wells were dependent. The effect of lowering the water table below sea level over such a considerable area and by such a depth would be to upset the existing stability of the saline / fresh water

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interface with a possible resulting detrimental impact on the groundwater quality at the production well sites.

The geotechnical consultants acting for the developers did not, in the opinion of Wexford County Council, give due consideration to the impact of such a huge dewatering programme on the saline / fresh water interface. The application was subsequently refused citing the following reasons:-

*'The proposed development would endanger the water supply system of south Wexford due to the operational needs of the proposed quarry in the limestone aquifer, which would be at risk from salt water intrusion resulting from the lowering of the level of the ground water. Insufficient information has been submitted on the quantity of ground water to be pumped from the quarry and on the location of the fresh water / salt water interface in the limestone aquifer and it is the opinion of the Planning Authority that a reduction in worklevels would risk contamination of the water supply by salt water. The proposed development would therefore be prejudicial to public health.'*

A second planning application for the limestone quarry was made in March, 1984, taking into account the hydrogeological problems associated with the original application. This new application intended to lower the water table by 3 m. and reduce the final quarry floor from 18 m. to 9 m. below existing ground level. The

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decrease in quarry depth being compensated by the increase of quarry floor area from 3 acres in the 1982 application to 13 acres in the revised application. Furthermore, the developers were now fully aware, following numerous meetings with Wexford County Council staff, of the potential risk of their dewatering operation to the County Council production wells and suggested that they would reduce the dewatering rate should it be seen to be affecting the groundwater abstractions from the limestone aquifer.

This second application was eventually granted one year later subject to some twenty conditions. An appeal to An Bord Pleanala and oral hearing followed, which resulted in a decision similar in almost all respects to that of Wexford County Council. The condition of planning relating specifically to protection of the aquifer, read as follows:

*'All de-watering operations shall cease immediately on the instructions of the Planning Authority, if in the opinion of that Authority the limestone aquifer is being, or is likely to be, adversely affected by the continuation of such de-watering operations. No pumping shall be resumed without the prior approval of the Planning Authority and in such circumstances any resumed pumping shall comply with the requirements of the Planning Authority in all respects. Before the commencement of development, the developer shall enter into an agreement with the Planning Authority as provided for by Section 38 of the Local*

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*Government (Planning & Development) Act, 1963 to comply with this condition.'*

2. The issue of saline intrusion and safe yields was also fully discussed in relation to the Fardystown Regional Water Supply Scheme's proposed abstraction of 5.8 m.g.d. of water from the South Wexford Limestone Aquifer. The proposed method of abstraction is designed to spread the lowering of the water table over as large an area as possible and to limit the cone of depression at each pumping station. This approach limits the impact of the withdrawal on the aquifer. The provision of six observation boreholes to the East and South of the aquifer will facilitate full monitoring of the salt water / fresh water interface. A flexible overall design will be adopted and the need to stage the development of source to match demand growth will allow design reappraisals in the light of updated aquifer pumping data.

## *CONCLUSION*

The need to protect valuable groundwater resources is self evident. The adoption and implementation of an effective Aquifer Protection Policy is now an essential element of the combined environmental legislative powers already in place to assist in such protection.

Wexford County Council is committed to maximum utilisation of its very extensive groundwater reserves. The high value placed on this resource is clearly recognised by Wexford County Council in actions taken to date and by the emphasis placed on groundwater protection in the County Development Plan.

Let us learn, as we are in the privileged position of so doing, from the mistakes and misfortune of other countries where the cost / benefit trade off to society may result in some groundwater aquifers being designated as permanently contaminated.

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## Article 24

### First Schedule

### Development for the purposes of these Regulations

### Part I

1. A crude-oil refinery (excluding an undertaking manufacturing only lubricants from crude oil) or an installation for the gasification and liquefaction of 500 tonnes or more of coal or bituminous shale per day.

2. A thermal power station or other combustion installation with a heat output of 300 megawatts or more, or a nuclear power station or other nuclear reactor (except a research installation for the production and conversion of fissionable and fertile materials, whose maximum power does not exceed 1 kilowatt continuous thermal load).

3. An installation designed solely for the permanent storage or final disposal of radioactive waste.

4. An integrated works for the initial melting of cast-iron and steel.



5. An installation for the extraction of asbestos or for the processing and transformation of asbestos or products containing asbestos:-

   (a) where the installation produces asbestos-cement products, with an annual production of more than 20,000 tonnes of finished products; or

   (b) where the installation produces friction material, with an annual production of more than 50 tonnes of finished products; or

   (c) in other cases, where the installation would utilise more than 200 tonnes of asbestos per year.

6. An integrated chemical installation.

7. A line for long-distance railway traffic, or an aerodrome with a basic runway length of 2,100 metres or more.

8. A trading port, or an inland waterway which permits the passage of vessels of over 1,350 tonnes or a port for inland waterway traffic capable of handling such vessels.

9. A waste disposal installation for the incineration or chemical treatment of hazardous waste, or the filling of land with such waste.

## Part II

1. Agriculture

(a) The use of uncultivated land or semi-natural areas for intensive agricultural purposes, where the area involved would be greater than 100 hectares.

(b) Water-management projects for agriculture, where the catchment area involved would be greater than 1000 hectares, or where more than 50 hectares of wetlands would be affected.

(c)(i) Initial afforestation, where the area involved would be greater than 200 hectares; the replacement of broadleaf high forest by conifer species, where the area involved would be greater than 10 hectares.



(ii) Land reclamation for the purposes of conversion to another type of land use, where the area involved would be greater than 100 hectares.

(d) Poultry-rearing installations, where the capacity would exceed 100,000 units and where units have the following equivalents;

1 broiler = 1 unit

1 layer, turkey or other fowl = 2 units.

(e) Pig-rearing installations, where the capacity would exceed 1000 units on gley soils or 3000 units on other soils and where units have the following equivalents;

1 pig = 1 unit

1 sow = 10 units.

(f) Seawater salmonid breeding installations with an output which would exceed 100 tonnes per annum; all salmonid breeding installations consisting of cage rearing in lakes; all salmonid breeding installations upstream of drinking water intakes; other freshwater salmonid breeding installations which would exceed 1 million smolts and with less than 1 cubic metre per second per 1 million smolts low flow diluting water.

(g) Reclamation of land from the sea, where the area of reclaimed land would be greater than 20 hectares.

2. Extractive Industry

(a) Peat extraction which would involve a new or extended area of 50 hectares.

(b) All geothermal drilling and drilling for the storage of nuclear waste material; drilling for water supplies where the expected supply would exceed 5,000 cubic metres per day.

(c) All extraction of minerals within the meaning of the Minerals Development Acts, 1940 to 1979.

(d) Extraction of stone, gravel, sand or clay, where the area involved would be greater than 5 hectares.

(e) All extraction of petroleum (excluding natural gas).



(f) All onshore extraction of natural gas; offshore extraction of natural gas where the extraction would take place within 10 kilometres of the shoreline.

(g) All surface industrial installations for the extraction of coal, petroleum (excluding natural gas), natural gas, ores, or bituminous shale.

(h) All coke ovens (dry coal distillation).

(i) All installations for the manufacture of cement.

3. Energy industry

(a) Industrial installations for the production of electricity, steam and hot water (other than installations comprehended by Part I of this Schedule) with a heat output of 300 megawatts or more.

(b) Industrial installations for carrying gas, steam and hot water with a potential heat output of 300 megawatts or more; transmission of electrical energy by overhead cables where the voltage would be 200 KV or more.

(c) Installations for surface storage of natural gas, where the storage capacity would exceed 200 tonnes.

(d) Installations for underground storage of combustible gases, where the storage capacity would exceed 200 tonnes.

(e) Installations for surface storage of fossil fuels, where the storage capacity would exceed 100,000 tonnes.

(f) Installations for industrial briquetting of coal and lignite, where the production capacity would exceed 150 tonnes per day.

(g) All installations for the production or enrichment of nuclear fuels.

(h) All installations for the reprocessing of irradiated nuclear fuels.

(i) All installations for the collection and processing of radioactive waste (other than installations comprehended by Part I of this Schedule).

(j) Installations for hydroelectric energy production with an output of 20 megawatts or more, or where the new or extended superficial area of water



impounded would be 30 hectares or more, or where there would be a 30 per cent. change in the maximum, minimum or mean flows in the main river channel.

4. Processing of metals

(a) Iron and steelworks, including foundries with a batch capacity of 5 tonnes or more, and forges, drawing plants and rolling mills where the production area would be greater than 500 square metres (other than installations comprehended by Part I of this Schedule).

(b) Installations for the production (including smelting, refining, drawing and rolling) of non-ferrous metals excluding precious metals, where the melting capacity would exceed 0.5 tonnes or where the production area would be greater than 500 square metres.

(c) Installations for pressing, drawing and stamping of large castings, where the production area would be greater than 500 square metres.

(d) Installations for surface treatment and coating of metals, where the production area would be greater than 100 square metres.

(e) Installations for boilermaking, manufacture of reservoirs, tanks and other sheet-metal containers, where the production area would be greater than 500 square metres.

(f) All installations for manufacture and assembly of motor vehicles and manufacture of motor-vehicle engines.

(g) Shipyards, where the area would be 5 hectares or more, or with capacity for vessels of 10,000 tonnes or more (deadweight).

(h) All installations for the construction of aircraft with a seating capacity exceeding 10 passengers.

(i) Manufacture of railway equipment, where the production area would be greater than 3000 square metres.

(j) Swaging by explosives, where the floor area involved would be greater than 100 square metres.

(k) All installations for the roasting and sintering of metallic ores.



5. Manufacture of glass

Installations for the manufacture of glass, where the production capacity would exceed 5,000 tonnes per annum.

6. Chemical Industry

(a) All installations for treatment of intermediate products and production of chemicals (other than installations comprehended by Part I of this Schedule).

(b) All installations for production of pesticides and pharmaceutical products, paint and varnishes, elastomers and peroxides.

(c) (i) Storage facilities for petroleum, where the storage capacity would exceed 50,000 tonnes,

(ii) Storage facilities for petrochemical and chemical products, where such facilities are isolated storage to which the provisions of Regulations 12 to 18 of the European Communities (Major Accident Hazards of Certain Industrial Activities) Regulations, 1986 (S.I. No. 292 of 1986) apply.

7. Food industry

(a) Installations for manufacture of vegetable and animal oils and fats, where the capacity for processing raw materials would exceed 40 tonnes per day.

(b) Installations for packing and canning of animal and vegetable products, where the capacity for processing raw materials would exceed 100 tonnes per day.

(c) Installations for manufacture of dairy products, where the processing capacity would exceed 50 million gallons of milk equivalent per annum.

(d) All installations for commercial brewing and distilling; installations for malting, where the production capacity would exceed 100,000 tonnes per annum.

(e) Installations for confectionery and syrup manufacture, where the production capacity would exceed 50,000 tonnes per annum.



(f) Installations for the slaughter of animals, where the daily capacity would exceed 1,500 units and where units have the following equivalents;

1 sheep = 1 unit

1 pig = 2 units

1 head of cattle = 5 units.

(g) All industrial starch manufacturing installations.

(h) All fish-meal and fish-oil factories.

(i) All sugar factories.

8. Textile, leather, wood and paper industries

(a) All wool scouring, degreasing or bleaching factories.

(b) All installations for manufacture of fibre board, particle board or plywood.

(c) All installations for manufacture of pulp, paper or board.

(d) Fibre-dyeing factories, where the dyeing capacity would exceed 1 tonne per day of fibre or yarn.

(e) Cellulose-processing and production installations, where the production capacity would exceed 10,000 tonnes per annum.

(f) Tannery, leather-dressing or fell-mongering factories, where the capacity would exceed 100 skins per day.

9. Rubber industry

Installations for manufacture and treatment of elastomer-based products, where the production capacity would exceed 10,000 tonnes per annum.

10. Infrastructure projects

(a) Industrial-estate development projects, where the area would exceed 15 hectares.

(b) Urban-development projects which would involve an area greater than 50 hectares in the case of projects for new or extended urban areas, and an area greater than 2 hectares within existing urban areas.



(c) Ski-lifts and cable-cars, where the length would exceed 500 metres.

(d) (i) construction of a new road (other than a motorway comprehended by the European Communities (Environmental Impact Assessment) (Motorways) Regulations, 1988 (S.I. No. 221 of 1988)) of four or more lanes, or the realignment or widening of an existing road so as to provide four or more lanes, where such new, realigned or widened road would be eight kilometres or more in length in a rural area, or 500 metres or more in length in an urban area.

(ii) construction of a new bridge which would be 100 metres or more in length.

(iii) new or extended harbours (other than a trading port comprehended by Part I of this Schedule), where the area, or additional area, of water enclosed would be 20 hectares or more, or which would involve the reclamation of 5 hectares or more of land, or which would involve the construction of additional quays exceeding 500 metres in length.

(iv) all aerodromes (other than aerodromes comprehended by Part I of this Schedule) with paved runways exceeding 800 metres in length.

(e) Canalization and flood-relief works, where the catchment area involved would be greater than 5000 hectares.

(f) Dams and other installations designed to hold water or to store it on a long-term basis, where the new or extended area of water impounded would be 30 hectares or more.

(g) All tramways, elevated and underground railways, suspended lines or similar lines of a particular type, used exclusively or mainly for passenger transport.

(h) Oil and gas pipelines exceeding 80 kilometres in length.



(i) Installation of overground aqueducts with a diameter of 1000 millimetres or more and a length of 500 metres or more.

(j) Sea water marinas where the number of berths would exceed 300 and fresh water marinas where the number of berths would exceed 100.

11. <u>Other projects</u>

(a) Holiday villages involving more than 100 holiday homes, stationary caravans or trailers; hotel complexes having an area of 20 hectares or more or an accommodation capacity exceeding 400 beds.

(b) All permanent racing and test tracks for cars and motor cycles.

(c) Installations for the disposal of industrial and domestic waste with an annual intake greater than 25,000 tonnes (other than installations comprehended by Part I of this Schedule).

(d) Waste water treatment plants with a capacity greater than 10,000 population equivalent.

(e) Sludge-deposition sites where the expected annual deposition is 5,000 tonnes of sludge (wet).

(f) Storage of scrap iron, where the site area would be greater than 5 hectares.

(g) Test benches for engines, turbines or reactors, where the floor area would exceed 500 square metres.

(h) All installations for manufacture of artificial mineral fibres.

(i) All installations for manufacture, packing, loading or placing in cartridges of gunpowder and explosives.

(j) All knackers' yards in built-up areas.

12. (a) All modifications of developments of a class mentioned in paragraph 3 or paragraph 9 of Part I of this Schedule; all modifications of nuclear power stations or other nuclear reactors (except research installations for the production and conversion of fissionable and fertile materials,



whose maximum power does not exceed one kilowatt continuous thermal load).

(b) Modifications of developments of a class mentioned in paragraphs 1, 2 (other than nuclear installations), 4, 5 or 6 of Part I of this Schedule which would increase the productive capacity of the development concerned by 20 per cent. or more.

(c) (i) Any extension of the runways of an aerodrome of a class mentioned in paragraph 7 of Part I of this Schedule which would increase the runway length by 30 per cent. or more.

(ii) Any modification of a port, inland waterway or inland waterway port of a class mentioned in paragraph 8 of Part I of this Schedule which would increase its traffic handling capacity by 20 per cent. or more.

Article 25

## Second Schedule

Information to be contained in an environmental impact statement

1. An environmental impact statement shall contain the information specified in paragraph 2 (referred to in this Schedule as "the specified information").

2. The specified information is -

   (a) a description of the development proposed, comprising information about the site and the design and size or scale of the development;

   (b) the data necessary to identify and assess the main effects which that development is likely to have on the environment;

   (c) a description of the likely significant effects, direct and indirect, on the environment of the development, explained by reference to its possible impact on -



human beings;

flora;

fauna;

soil;

water;

air;

climate;

the landscape;

the inter-action between any of the foregoing;

material assets;

the cultural heritage;

   (d) where significant adverse effects are identified with respect to any of the foregoing, a description of the measures envisaged in order to avoid, reduce or remedy those effects; and

   (e) a summary in non-technical language of the information specified above.

3. An environmental impact statement may include, by way of explanation or amplification of any specified information, further information on any of the following matters -

(a) the physical characteristics of the proposed development, and the land-use requirements during the construction and operational phases;

(b) the main characteristics of the production processes proposed, including the nature and quantity of the materials to be used;

(c) the estimated type and quantity of expected residues and emissions (including pollutants of surface water and groundwater, air, soil and substrata, noise, vibration, light, heat and radiation) resulting from the proposed development when in operation;

(d) (in outline) the main alternatives (if any) studied by the applicant, appellant or authority and an indication of the main reasons for choosing the development proposed, taking into account the environmental effects;

(e) the likely significant direct and indirect effects on the environment of the development proposed which may result from -



(i) the use of natural resources;

(ii) the emission of pollutants, the creation of nuisances, and the elimination of waste;

(f) the forecasting methods used to assess any effects on the environment about which information is given under subparagraph (e); and

(g) any difficulties, such as technical deficiencies or lack of knowledge, encountered in compiling any specified information.

In paragraph (e), "effects" includes secondary, cumulative, short, medium and long term, permanent, temporary, positive and negative effects.

4. Where further information is included in an environmental impact statement pursuant to paragraph 3, a non-technical summary of that information shall also be provided.

GIVEN under the Official Seal
of the Minister for the Environment
this 19th day of December, 1989.

L.S. Padraig Flynn

Minister for the Environment.

EXPLANATORY NOTE

(This note is not part of the Instrument and does not purport to be a legal interpretation).

These Regulations provide for the incorporation into Irish law, in respect of relevant development other than motorways, of Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment. Effect was given to this Directive in respect of motorways by the European Communities (Environmental Impact Assessment) Regulations, 1988 (S.I. No. 221 of 1988).

The Regulations modify the provisions of the Local Government (Planning and Development) Acts, 1963 to 1983 so as to provide a framework for the application of Environmental Impact Assessment (EIA) to the planning control procedures under those Acts, and for the application of EIA to relevant development by local authorities. They also modify development consent procedures under 9 other enactments in light of the Directive's requirements, and they establish an EIA procedure for relevant development by State authorities.

**Industry, Groundwater and E.I.A.'s**

**by Kevin T. Cullen & Company Ltd.**

## ABSTRACT

The groundwater aspect of environmental impact statements for industrial projects should be only a minor part of such studies. Following on from costly failures at older plants the modern design engineer will attempt to design out any possible impact on local groundwater resources. This approach avoids the possibility of future clean up costs for his client and meets local authority licensing demands.

Therefore, an E.I.A. should consider (a) the design parameters built into the project to prevent groundwater contamination; (b) the value of the local groundwater resource and (c) the potential damage that might result from an uncontrolled spillage. Recommendations might include additional measures to collect leakages and the location of monitoring boreholes to provide regular groundwater sampling stations. In this regard, a clear understanding of the geological structure of the site is necessary to ensure that the monitoring boreholes are located and constructed in a manner that will ensure detection of any contamination plume.

Likely significant impacts might arise from effluent percolation areas where foul effluent is discharged to the ground. Also, the lowering of the water table may be associated with a large withdrawal of groundwater for process waters. In both cases field studies would be required to determine the nature and likely extent of the impact.