INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS (IRISH GROUP)

6TH ANNUAL SEMINAR

THE HYDROGEOLOGY AND MANAGEMENT OF LANDFILL SITES

AT

KILLESHIN HOTEL, PORTLAOISE.

P R O G R A M M E

	Item	Speaker	Organisation
Tuesday 22nd April			
10.30 a.m.	Registration and Coffee		
10.45 a.m.	Welcome and Introduction		
11.00 a.m.	Legislation and Waste Management	Mr. O. Boyle	Dept. of the Environment
11.45 a.m.	Toxic Wastes and Groundwater Contamination	Dr. S. Ragone	U.S. Geological Survey
12.45 p.m.	Discussion		
1.00 p.m.	Lunch		
2.30 p.m.	Landfill Sites and the Environment	Mr. D. Daly	Geological Survey of Ireland
3.00 p.m.	The Ballyogan Site, Co.Dublin	Mr. M. Lorrigan	Dublin County Council
3.30 p.m.	Discussion		
3.45 p.m.	Coffee		
4.00 p.m.	The Collon Site, Co. Louth	Mr. D. O'Neill Mr. J. Lucas	Louth County Council Aspinwall & Co.
4.30 p.m.	The Disposal of Industrial Wastes	Dr. E. McMahon	I.I.R.S.
5.00 p.m.	Discussion and Close		
5.30 p.m.	Exhibits		
Wednesday 23rd April			
9.30 a.m.	Landfill Assessment Practices	Ms. B. Naughton	An Foras Forbartha
10.00 a.m.	The Kilcullen Site, Co.Kildare	Mr. D. O'Connor	Kildare County Council
10.30 a.m.	The Portlaoise Site, Co.Laois	Mr. S. Peel	Minerex Limited
11.00 a.m.	Coffee		
11.15 a.m.	A Lined Site in Southern England	Mr. K. Knox	Cleanaway Limited
11.45 a.m.	An Estuary Site in Belfast	Mr. P. Bennett	Geological Survey of Northern Ireland
12.15 p.m.	Panel Discussion		
12.45 p.m.	Close and Lunch		

International Association of Hydrogeologists - Irish Group.

Hydrogeology and Management of Landfill Sites - 1986.

List of Delegates

Mr. Mainul Ahsan	University College, Galway.
Mr. Robert Aldwell	Geological Survey of Ireland.
Mr. Peter Bennett	Geological Survey of Northern Ireland.
Mr. Owen Boyle	Department of the Environment.
Mr. Seamus Byrne	Wexford County Council.
Ms. Marian Byron	Environmental Science Unit, Trinity College.
Mr. Edward Carr	Donegal County Council.
Mr. Alan Chapple	Kirk McClure & Morton.
Ms. Catherine Coxon	Environmental Science Unit, Trinity College.
Mr. Fergus Coyle	Monaghan County Council.
Mr. Edward Creed	N. O'Dwyer & Partners
Mr. Tom Cross	Brosna, Co. Kerry.
Mr. Patrick Crowe	Tipperary (N.R.) County Council.
Mr. Kevin T. Cullen	Consultant.
Mr. Malachi Cullen	Stanislaus Kenny & Partners.
Mr. Eugene Daly	Geological Survey of Ireland.
Mr. Donal Daly	Geological Survey of Ireland.
Mr. Hans Danford	University College Galway.
Mr. Daniel Duggan	Wexford County Council.
Mr. Ronnie Dunne	Department of the Environment.
Mr. Patrick Dunne	Dunnes Water Services Ltd.
Mr. Richard Faherty	Galway County Council.
Mr. Padraig Fallon	Louth County Council.
Ms. Katherine Farrell	Johnson Well Screens Limited.
Mr. Jim Finlay	Kirk McClure & Morton.

Mr. Thomas Fitzpatrick	Westmeath County Council.
Mr. Gerard Forde	Wexford County Council.
Mr. Joseph Forristal	Wicklow County Council.
Mr. Frank Fury	Department of the Environment.
Mr. Thomas Geraghty	Department of the Environment.
Mr. Michael Hand	P.H. McCarthy Son & Partners.
Mr. John Higginson	Carlow County Council.
Mr. L.K. Jawara	University College Galway.
Mr. Patrick Johnston	Aspinwall & Company.
Mr. Paul Johnston	University College Galway.
Mr. Noel Kane	Thomas Garland & Partners.
Mr. M.S. Kawa Sierra Leone	University College Galway.
Mr. Jia Keli	University College Galway.
Mr. Edward Kilcullen	University College Galway.
Mr. Thomas Kilgarriff	Cavan County Council.
Mr. Michael King	University College Galway.
Dr. Keith Knox	Cleanaway Limited.
Mr. Brian Leech	Department of the Environment.
Mr. Michael Looby	Offaly County Council.
Mr. Michael Lorrigan	Dublin County Council.
Mr. John Lucas	Aspinwall & Company.
Mr. Matthew Lynch	Water Pollution Advisory Council
Mr. J. S. Malone	Tipperary (N.R.) County Council.
Mr. Eamonn Mansfield	Waterford County Council
Mr. Eamonn Markey	Department of the Environment
Mr. Donal Marron	Cullen & Company.
Mr. Raymond McGee	Department of the Enviroment.
Mr. John McGrath	Cork County Council.

Mr. Ciaran McGrath	Westmeath County Council
Dr. Emmet McMahon	Institute of Industrial Research and Standards.
Mr. N. J. McMahon	Patrick J. Sheahan & Partners.
Mr. Thomas Mulcahy	Waterford County Council.
Mr. Philip Munah	University College Galway
Mr. Henry Murdoch	Cleanaway Ireland Limited.
Mr. William Murphy	Cork County Council.
Mr. Johnny Nah	University College Galway.
Ms. Breda Naughton	An Foras Forbartha.
Mr. Colm O'Boyle	Central Waste Paper Company Limited
Mr. Sean O'Breasail	Cork County Council.
Mr. Danny O'Connor	Dublin County Council.
Mr. Desmond O'Connor	Kildare County Council.
Mr. Barry O'Donovan	Carrbrook Chemicals Irl. Ltd.
Mr. Kieran O'Dwyer	Cullen & Company.
Mr. Diarmuid O'Grada	An Bord Pleanala.
Mr. Muiris O'Keeffe	Wicklow County Council.
Mr. Damien O'Neill	Louth County Council.
Ms. Suzanne O'Sullivan	Environmental Science Unit, Trinity College.
Mr. Stephen Peel	Minerex Limited.
Dr. Stephen Ragone	U.S. Geological Survey.
Mr. Patrick Rouse	Offaly County Council.
Mr. Pedro Sanchez	University College Galway.
Mr. William Scott	Kilkenny County Council.
Mr. James Shine	Waterford County Council.
Mr. S. Simafar	University College Galway.
Mr. William Smyth	Geological Survey of Northern Ireland.
Mr. Kenneth Spellman	Louth County Council.

Mr. Merlin Stanley	Water Pollution Advisory Council.
Mr. Niall Sweeney	Laois County Council.
Dr. Richard Thorn	Sligo Regional College.
Mr. Padraig Thornton	An Bord Pleanala.
Dr. Kyran Vallom	Institute of Industrial Research & Standards.
Mr. Vu Van Tuan	University College Galway.
Mr. William Walsh	Laois County Council.
Mr. Geoff Warke	Geological Survey of Northern Ireland.
Mr. Patrick White	John B. Barry & Partners.
Mr. John Woodlock	Environmental Science Unit, Trinity College.
Mr. Geoff Wright	Geological Survey of Ireland.

This SEMINAR has been organised by the Committee of the IRISH GROUP of the INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS:

MR. PETER BENNETT, PRESIDENT.

MS. BREDA NAUGHTON, SECRETARY.

MR. KEVIN CULLEN, TREASURER.

The organisers wish to thank all the Speakers and their organisations for their presentations, and the Management and Staff of the Killeshin Hotel.

LEGISLATION AND WASTE MANAGEMENT

by

OWEN C. BOYLE, B.E., M.Sc., M.P.A.

1. <u>General</u>

Until recent years the legislative powers available to the local authorities in Ireland were not suited to control the waste disposal problems of a modern industrial society. As will be shown below, their powers under the Sanitary Services Code were inadequate, and they could fall back only on the control provisions of the Planning Acts.

Mainly as a result of the Regulations necessary to implement E.E.C. Directives, the local authorities now have much better control provisions available to them for the authorisation and supervision of waste disposal operations.

2. <u>Pre-E.E.C. Legislation</u>

<u>The Sanitary Services Code</u>

Under the Public Health Act of 1878 (Section 52) sanitary authorities are empowered, and may be required by the Minister for the Environment, to undertake the removal of <u>household refuse</u>. The Public Health Acts, Amendment Act, 1907 (Section 48) requires a local authority to remove any "<u>trade refuse</u>" if they are requested to do so by the owner or occupier of a premises.

Protection of public health is provided for under the Public Health (Ireland) Act, 1878 and a number of amending statutes, including the Sanitary Services Acts of 1948, 1962 and 1964, the whole of which is referred to as "the Local Government (Sanitary Services) Acts, 1878 to 1964". The Code includes provisions for legislative control over "<u>nuisances</u>".

The original Public Health Act 1878 gave to "sanitary authorities" the responsibility for implementing the provisions of the Act. Sanitary authorities are all of the county borough and borough corporations, the county councils and urban district councils. Section 110 of the Act provides the sanitary authorities with a summary procedure for dealing with "nuisances" as defined under the Act. The procedure involves the serving of a notice on the person "by whose act, default or sufferance the nuisance arises or continues", and the issue of a summons in the

District Court if the person served with the notice does not comply within the specified time.

The Act provides that any aggrieved person, and certain other categories of persons, may give information of a nuisance to the sanitary authority. It is also the duty of the sanitary authorities to inspect their districts to detect nuisances from time to time, and to take steps to abate such nuisances. The category of nuisance of relevance here is "any accumulation or deposit which is a nuisance or injurious to health". Sanitary authorities may use the summary procedures laid out in the Act to control such nuisances.

The Planning Acts

The Planning Acts are widely used by planning authorities to control trade waste disposal in the case of new industries by attaching appropriate conditions to the planning permission.

In addition, it is necessary to acquire planning permission for the development and operation of private waste disposal sites. Local authorities, of course, are exempted from this requirement if the site is in their own area.

Section 52 of the 1963 Act which prohibited the creation of litter or the deposit of waste material on streets, road sides, or open spaces ~~(a summary procedure is provided to the local authorities for dealing with offenders)~~ has been repealed under the Litter Act, 1982.

3. The Litter Act, 1982

For the purposes of the Litter Act, "local authority" means the council of a county, the corporation of a county or other borough, or the council of an urban district.

The Act requires local authorities to take measures for the prevention of litter and for dealing with litter in their areas. It introduces an 'on-the-spot' fine system to be operated by the local authorities for litter offences. The local authorities have been given enforcement powers over a range of offences such as littering, graffiti, flyposting, the abandonment of vehicles, and accumulations of vehicles and disused articles. The Act requires occupiers of land to keep it free of litter which is in, or is visible from a public place. The local authorities are also required to make provision for the disposal of vehicles and scrap metal.

4. E.E.C. Legislation on Waste

Five Directives have been adopted to date by the Council of Ministers on the subject of waste disposal. These are as follows:

(i) Council Directive of 16 June 1975 on the disposal of waste oils (75/439/EEC)

(ii) Council Directive of 15 July 1975 on waste (75/442/EEC)

(iii) Council Directive of 6 April 1976 on disposal of polychlorinated biphenyls and polychlorinated terphenyls (76/403/EEC)

(iv) Council Directive of 20 March 1978 on toxic and dangerous waste (78/319/EEC)

(v) Council Directive 78/176/EEC on waste from the titanium dioxide industry.

The first four of these Directives are discussed in the following sections of this paper. The last is omitted from discussion since we do not have a titanium dioxide industry in Ireland.

For the purpose of the Regulations giving effect to the four Directives, "local authority" can be taken to mean county borough corporations, county councils and Dun Laoghaire borough corporation.

5. Council Directive on Disposal of Waste Oils (75/439/EEC)

This Directive is being implemented in Ireland under the European Community (Waste Oil) Regulations, 1984 (S.I. No. 107 of 1984). Its objectives are twofold:

(i) To ensure that, as far as possible, waste oils are recycled, whether by regeneration or combustion.

(ii) To avoid pollution of water, air or soil.

The Regulations make local authorities responsible for the planning, organisation and supervision of disposal operations. Waste oil disposal undertakings are to be controlled by means of a permit system under Article 4 of the Regulations. The permit system applies to actual disposal undertakings only and not to persons collecting or storing waste oils for disposal. Local authorities are, however, empowered to require the keeping of records in respect of any premises on which more than 500 litres of waste oil is produced, collected or disposed of annually and may appoint an "authorised person" for inspection purposes. Advice on implementation of the Regulations is given to local authorities in Circular Letter ENV 7/84 dated 2 May 1984.

Article 16 of the Directive requires Member States to send to the E.E.C. Commission, a situation report on the disposal of waste oils every three years. The last such report was submitted by Ireland in April 1982. It will be necessary for local authorities to assemble comprehensive statistics of waste oil arisings and disposal for the purposes of a more detailed report in 1985.

6. Council Directive of 15 July 1975 on Waste 75/442/EEC

The European Communities (Waste) Regulations, 1979 (S.I. No. 390 of 1979) give effect to this Directive in Ireland. Advice on implementation is given in Circular Letter ENV 2/80 of 20 February 1980. Other documents of interest in this regard include:

- ENV 10/78, "Waste Disposal Plan", dated 19 April 1978
- ENV 4/79, "Disposal of Industrial Waste", dated 12 July 1979
- GIS Statement, "Strategy for Waste Disposal", dated 18 May 1981
- ENV 5/81 of 4 June 1981
- ENV 1/82 of 5 March 1982
- ENV 10/82, "Provision of Co-Disposal Sites for Industrial and Other Wastes", not dated.

The E.C. (Waste) Regulations, 1979 define a "public waste collector" as a local or other sanitary authority for the purposes of the Local Government (Sanitary Services) Acts, 1878 to 1964. The responsibilities of sanitary authorities with regard to the collection and disposal of waste under the Sanitary Services Acts are not affected by these Regulations.

A "waste operation" means the collection, sorting, transport and treatment of waste as well as its storage and tipping above and under ground and the transformation operations necessary for its re-use, recovery or re-cycling.

A person other than a public waste collector may not carry out the treating, storing or tipping of waste on behalf of another person without an appropriate permit issued by a local authority under Article 5 of the Regulations. The holder of a permit must keep a detailed register of his operations for inspection by any authorised person.

The holder of a waste may dispose of the waste himself in a manner which will not endanger human health or the environment. If he does not himself dispose of the waste, he may not permit disposal by any person other than a public waste collector or the holder of a permit. 'Disposal' in this sense means the treating, tipping or storing of waste. Alternatively, the holder of waste may export the waste for disposal. In addition, the dumping of waste at sea is licensable by the Department of Communications under the Dumping at Sea Act, 1981.

The Regulations make local authorities responsible for the planning, organisation, authorisation and supervision of waste operations in their areas. This responsibility relates to all types of waste (other than those excluded under Articles 8, i.e.:

(a) radioactive waste

(b) waste resulting from prospecting, extraction, treatment and storage of mineral resources and the working of quarries

(c) animal carcases and agricultural waste comprising faecal matter or substances used in farming

(d) waste waters (but not including waste in liquid form)

(e) gaseous effluents emitted into the atmosphere.)

Under the Regulations local authorities are statutorily obliged to prepare waste disposal plans for their areas.

The responsibility for "supervision" by local authorities encompasses all public and private sector waste operations in their areas. This includes operations carried out by sanitary authorities, private waste disposal firms and producers/holders who dispose of their own wastes. Persons collecting or transporting waste on behalf of others do not require a permit under the Regulations, but are subject to the supervisory powers of the local authorities. In addition to the obligation on permit holders to keep registers of operations, a local authority may also direct in writing any other person transporting, collecting, treating, tipping and/or storing their own waste or collecting and/or transporting waste on behalf of others to maintain a similar register.

7. Council Directive of 6 April 1976 on Disposal of PCB's (76/403/EEC)

The E.C. (Waste) (No. 2) Regulations, (S.I. No. 388 of 1979) were made in 1979 to implement this Directive.

Under the 1979 Regulations the Electricity Supply Board was nominated as the designated authority for disposal of waste PCB. The E.S.B. indicated that it wished to relinquish this role, and the European Community (Waste) Regulations, 1984 were made in order to provide alternative arrangements.

The 1984 Regulations oblige a holder of waste PCB to:

(a) notify the Minister of such holding and the manner in which it is proposed to dispose of it

(b) comply with any directions given by the Minister or by an authorised person in relation to such disposal

(c) provide evidence, if so required, of the manner in which PCB waste has been disposed of.

The direction in relation to disposal may specify the undertaking at which the disposal is to take place.

The new Regulations also provide for the appointment of an "authorised person" by the Minister and Mr. E. Markey, Environmental Inspector, Department of the Environment, has been appointed accordingly. His functions are mainly supervisory and he is available to advise local authorities in relation to any PCB disposal problems or queries.

Advice on the properties and occurrence of PCB, and on implementation of the 1984 Regulations is given in Circular Letter ENV 6/84 dated 30 April 1984. Local authorities are requested to co-operate generally in ensuring that safe disposal arrangements are made. It is suggested that in conjunction with their supervision of toxic and dangerous wastes they may seek to identify and record holders/users of equipment containing PCB and advise such holder/users of the dangerous nature of PCB and of their obligations under the regulations.

8. Council Directive of 20 March 1978 on Toxic and Dangerous Waste (78/319/EEC)

This Directive is being implemented in Ireland under the European Communities (Toxic and Dangerous Waste) Regulations, 1982 (S.I. No. 33 of 1982). A Memorandum for the Guidance of Local Authorities has been issued to the local authorities.

Other documents of interest in this regard include:

- Circular ENV 12/78
- Circular ENV 1/82
- Circular ENV 19/82
- G.I.S. Statement on "Strategy for Disposal of Hazardous Wastes", dated 3 March 1982
- Circular on "Disposal of Prohibited Pesticides Products", dated April 1984

Appendix I to this paper gives a list of the 27 categories of wastes which are defined in the Directive as "toxic and dangerous waste". The 1982 Regulations use the same definition. The Regulations do not apply to:

(a) radioactive waste
(b) animal carcases and agricultural waste of faecal origin
(c) explosives
(d) hospital waste
(e) effluents discharged into sewers and watercourse
(f) emissions to the atmosphere
(g) household waste
(h) mining waste
(i) other toxic and dangerous waste covered by specific Community rules.

Furthermore, the European Communities (Waste) Regulations, 1979 (S.I. No. 390 of 1979) do not apply to toxic and dangerous waste.

The 1982 Regulations make local authorities responsible for the planning, organisation, and supervision of operations for the disposal of toxic and dangerous waste in their areas and for the authorisation of the storage, treatment and depositing of such waste.

Each local authority must prepare a "special waste plan" which will indicate:

(a) the types and quantities of toxic and dangerous waste to be disposed of
(b) the methods of disposal
(c) specialised treatment centres where necessary
(d) suitable disposal sites.

Notice of the making or variation of a special waste plan must be published in at least one newspaper circulating in the area, and a copy of the plan must be made available for public inspection.

Article 5 of the Regulations requires that <u>any</u> person, other than a local authority acting in its own area, who stores, treats or deposits toxic and dangerous waste may do so only in accordance with a permit issued by the local authority in whose area the operation is carried out. It should be noted that the obligation to obtain a permit extends to:

(a) a local authority operating in the area of another local authority

(b) sanitary authorities which are not local authorities within the meaning of the Regulations

(c) producers who store, treat or deposit their own wastes

(d) undertakings who do so for others.

Persons producing or holding toxic and dangerous waste without a permit are obliged to have the waste stored, treated or deposited as soon as possible by a person holding an appropriate permit or by a local authority. Export of waste for disposal can be regarded as complying with the Regulations.

A permit is not required for the transport of toxic and dangerous waste. Responsibility for ensuring that the waste is disposed of in a proper manner falls, accordingly, on the permit holder who operates the disposal site, rather than on the person who transports, and who actually may deposit the waste on the site.

Article 6 of the Regulations deals mainly with the segregation of incompatible wastes and with the separate storage and proper labelling of toxic and dangerous waste.

Article 7 requires permit holders and any person producing, holding or disposing of toxic and dangerous waste to maintain a register of such operations.

Article 8 provides for a system of consignment notes to regulate the manner in which toxic and dangerous wastes are transported. Consignment notes are provided by the Department of the Environment to local authorities for distribution to intended users. The system is designed to follow the course of any consignment of toxic and dangerous waste from its origin to its destination, whether within or without the State. The procedures to be adopted by the various parties are set out clearly in the 1982 Regulations.

It would seem desirable that each local authority should keep records of consignment notes in respect of:

(i) numbers of forms issued by them and to whom

(ii) waste produced or held in their area which are consigned to other local authority areas

(iii) waste exported from the State out of their area

(iv) waste entering their area.

The local authorities have also been advised that, in addition to keeping the forms, a register of the data which they contain should be kept (in a computerised form, if possible).

Article 8 also requires exporters of toxic and dangerous waste to obtain documentary evidence that the waste has arrived at its destination, or to inform the local authority why they have been unable to obtain this evidence. Periodic checks should made to prevent the illegal disposal of toxic and dangerous waste under cover of pretended export.

Article 9 gives wide powers of entry and inspection to authorised officers appointed by a local authority or by the Minister.

9. Dumping at Sea

The dumping of wastes at sea is governed internationally by the Oslo and London Conventions which are implemented in Ireland under the Dumping at Sea Act, 1981. In general, it is an offence under this Act deliberately to dump any substance or material at sea, or even to load such material on to a vessel, aircraft or marine structure in the State for dumping, except in accordance with a permit issued by the Minister for Communications, after consultation with certain other Ministers, including the Minister for Fisheries and Forestry and the Minister for the Environment.

10. Conclusions

The Sanitary Services Code is generally regarded as outdated in its provisions relating to control over the disposal of waste. The procedures for enforcement are protracted, it can be difficult to prove that a 'nuisance' under the Act exists and, even where a conviction is achieved, the penalties are far too low. Legislation directed at planning development and control is generally not entirely suited to the continuing problems of environmental protection.

The new Dumping at Sea Act, 1981 and the Litter Act, 1982 provide important new systems of control within their areas of application. The Regulations made in order to implement E.E.C. legislation considerably strengthen local authority powers to control waste disposal operations.

There would seem to be a need, however, for a more comprehensive approach to the present somewhat fragmented system of legislation governing waste disposal. The Minister for the environment has already indicated that it is the intention that legislation relating to environmental protection should be further improved and developed, and that the law governing waste disposal is under review.

Post-script:

On 6 December, 1984 a Directive on Transfrontier Shipment of Hazardous Waste (84/631/EEC) was adopted by the Council of the European Communities. The main purpose of this Directive is to control transfrontier shipment of toxic and dangerous waste within the Community by an inter-country system of monitoring and supervision. Also covered by the Directive are wastes transhipped for use recycling or recovery. The Directive supplements earlier community legislation on toxic and dangerous waste which provided for control within national boundaries only.

APPENDIX I

Definition of Toxic and Dangerous Waste

Under the European Communities (Toxic and Dangerous Waste) Regulations, 1982:

Waste containing or contaminated by the substances listed below, of such a nature, in such quantities or in such concentration as to constitute a risk to health or the environment is defined as "toxic and dangerous waste".

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1. Arsenic; arsenic compounds
2. mercury; mercury compounds
3. Cadmium; cadmium compounds
4. Thallium; thallium compounds
5. Beryllium; beryllium compounds
6. Chrome 6 compounds
7. Lead; lead compounds
8. Antimony; antimony compounds
9. Phenols; phenol compounds
10. Cyanides, organic and inorganic
11. Isocyanates
12. Organic-halogen compounds, excluding inert polymeric materials and other substances referred to in this list or covered by other Directives concerning the disposal of toxic or dangerous waste.

13. Chlorinated solvents

14. Organic solvents

15. Biocides and phyto-pharmaceutical substances

16. Tarry materials from refining and tar residues from distilling

17. Pharmaceutical compounds

18. Peroxides, chlorates, perchlorates and azides

19. Ethers

20. Chemical laboratory materials, not identifiable and/or new, whose effects on the environment are not known.

21. Asbestos (dust and fibres)

22. Selenium; selenium compounds

23. Tellurium; tellurium compounds

24. Aromatic polycyclic compounds (with carcinogenic effects)

25. Metal carbonyls

26. Soluble copper compounds

27. Acids and/or basic substances used in the surface treatment and finishing of metals.

Note: For a list of potential sources of the above categories of wastes, see Appendix A to the Memorandum for the Guidance of Local Authorities on the E.C. (Toxic and Dangerous Waste) Regulations, 1982.

WASTE DISPOSAL SITES AND THE ENVIRONMENT

DONAL DALY

Geological Survey of Irland
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WASTE DISPOSAL SITES AND THE ENVIRONMENT

1. INTRODUCTION

The disposal of domestic and industrial wastes in tip sites can cause various adverse environmental effects. Many examples of actual adverse effects are present both in Ireland and abroad although in Ireland sofar we appear to have avoided major problems. However the character of waste is changing and the quantity is increasing in Ireland. Domestic refuse now contains higher quantities of plastics and paper packaging material (McGee 1979) and small quantities of relatively hazardous wastes. Industrial wastes are likely to increase in line with industrial development. In addition the public have become more aware of environmental pollution. As a result of bad site selection and operational practices in the past, public protests against proposed sites are a major problem for local authorities. Consequently, a major aspect of solid waste management and disposal is the consideration, assessment and prevention of adverse environmental effects.

This paper is not a comprehensive review of the various potential environmental effects from waste disposal sites. The main emphasis is on water pollution, particularly groundwater pollution. Geotechnical guidelines for the selection, design and management of waste disposal sites have already been produced by the Geological Survey (Daly and Wright, 1982). The aims of this paper are: 1) to review and update some of the aspects covered in the geotechnical guidelines; 2) to raise points which other speakers can address and 3) to ask questions which need to be considered by authorities and individuals involved with tip sites and environmental protection.

2. GROUNDWATER QUALITY AND POLLUTION - GENERAL SITUATION

Groundwater is a major natural resource in Ireland, supplying about 25% of total water usage. Groundwater quality in Irish aquifers is generally good and contamination is not a widespread problem. However, a number of local, usually minor, problems have come to the attention of the Geological Survey where wells have been polluted by point pollution sources. In some areas of highly fissured limestone the pollution is more widespread and serious with over 50% of wells containing E-coli and/or high ammonia levels.

The main sources of groundwater pollution in Ireland are septic tank effluent and farmyard wastes. When compared to these two sources tip sites are, at least to date, relatively minor sources if only because they are far less numerous.

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However this is no reason for complacency or for not giving them a higher priority than has been the case in the past because:

1. At a tip site, a large volume of waste, which produces a noxious leachate, is stored in a small area and consequently there is the potential for severe local pollution.
2. Some of the wastes may be hazardous and could result in toxic or dangerous substances entering water.
3. The sites are usually owned and managed by the Local Authority who should lead by example in minimising adverse environmental effects.
4. Because of its small size and because it is designed and managed by a local authority, a tip site is amenable to pollution control in a way that septic tanks and farmyards are not.

Groundwater is less prone to pollution than surface water because it is protected by an overlying soil and rock cover. However because it occurs underground, out of sight, pollution may have no obvious symptoms such as fish kills, sewage fungus or odour. When contamination affects a groundwater supply source, some indications may occur, but usually only when the level of pollution is very high. More commonly the pollutants are colourless and odourless and occur in low but significant concentrations. Moreover, when pollution does become obvious, it is often difficult to locate the pollution source.

A pollutant usually enters the groundwater system from the land surface, percolati down through the unsaturated zone until it reaches the water table. In the unsaturated zone attenuation may occur due to physical, chemical and biological processes - filtration, dilution, iron exchange, adsorption, precipitation and microbial action. This zone is generally considered to be a crucial area in attenuating many pollutants. Once in the saturated zone, the pollutant moves with the groundwater forming a plume of pollution. Due to dispersion the plume generally widens and thickens as it travels. Attenuation occurs mainly by dilution but also by other chemical and biochemical processes. The extent of pollution depends on the pollution source and on the hydrogeological situation.

3. WASTE DISPOSAL SITES AND THE ENVIRONMENT.

Waste disposal sites can cause the following adverse enviromental effects:

1. water pollution,
2. visual intrusion,
3. wind-blown litter,

4. odour nuisance,
5. fires,
6. vermin and birds,
7. gas migration,
8. Noise and traffic.

This paper is concerned only with water pollution, in particular with groundwater pollution. However, by operating a site so as to have minimal effects on water, many of the problems are also solved. For instance, covering the waste reduces the generation of leachate, but also reduces problems from litter, vermin, birds and fires.

One of the consequences of the tipping of wastes is the generation of leachate, which is the noxious liquid that is produced as a result of the interactions in the waste as water passes through it. It is this liquid that causes water pollution, and good site selection, design and operation are aimed mainly at its control.

Table 1 gives data on the range of leachate composition. The concentrations of the various substances vary depending on a variety of factors such as the waste being tipped, water content, design and operation of site, and the age of the waste.

During the 1970s a lot of research was conducted to assess the mobility of metals such as cadmium (Cd), nickel (Ni), mercury (Hg), zinc (Zn) chromium (Cr), lead (Pb), copper (Cu), selenium (Se) and arsenic (As) through soils and rocks and their potential as pollutants. It was found that generally they do not cause problems although the chemical behaviour depends on the redox and pH conditions of the contaminated groundwater (Cherry et al., 1984). Under normal groundwater pH conditions (close to neutral) metals are not generally mobile. Chromium and selenium are exceptions and tend to be mobile under aerobic conditions. Chromium has probably caused the most degradation of groundwater in North America. The other metals are rarely a problem except in conditions of very low or very high pH or where a single or dominant waste type, of industrial origin, is deposited in a tip site located in an unfavourable hydrogeological area. The most important metal contaminant in the Irish situation is likely to be iron. The leachate from domestic and co-disposal sites causes reducing conditions in the aquifer which brings iron into solution from the aquifer material. Also the leachate itself contains iron in solution.

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The other main inorganic contaminants of leachate are ammonia, boron, chloride and hardness. Of these, ammonia is the most significant, particularly in surface water where it can be toxic to fish at concentrations as low as 1 mg/l. Chloride is a mobile constituent which is often used as an indicator of contamination, although boron, iron, ammonia and dissolved solids are probably better inorganic indicators (Clark and Piskin, 1977).

In recent years new contaminants have now come to the attention of scientists and engineers in the water industry. These are complex organic compounds and are given special mention in this paper as they have become a major problem in some developed countries and attention has not previously been drawn to their occurrence as contaminants in this country.

4. ORGANIC CONTAMINANTS

4.1 Introduction

The number and quantity of organic chemicals that are produced has increased at a phenomenal rate since 1945. More than 40,000 organic compounds are currently manufactured (Cherry etal, 1984) and this increases by 1000 - 1500 every year (Schwarzenback, 1986). Many of these chemicals are hazardous or potentially hazardous. With improvements in the technology of analytical chemistry and the recognition that low-level organic contamination is a potential health hazard, many instances of organic contamination of groundwater are being identified in North America and Europe. Particularly worrying from a groundwater point of view is that contamination of drinking water supplies by toxic organic chemicals is worse for groundwater supplies than for surface water supplies (Burmaster, 1982).

There are many potential sources of groundwater contamination by organic compounds - spills, leaks, septic tanks, spraying of herbicides and pesticides, and waste disposal sites. It is worth noting, in view of the present emphasis on the development of the computer industry in Ireland, that this is one of the dirtiest industries in North America from a groundwater viewpoint as it uses large quantities of organic solvents (Cherry, pers. comm.).

TABLE 1

Typical Composition of Leachates from Domestic Wastes at Various Stages of Decomposition (all results in mg/l except pH-value)

Determinand		(1) Leachate A (recent wastes)	(2) Leachate B (aged wastes)	(3) Leachate C (bioreactivewastes)
pH value		6.2	7.5	8.0
COD (Chemical Oxygen Demand)		23 800	1 160	1 500
BOD_5 (Biochemical Oxygen Demand)		11 900	260	500
TOC (Total Organic Carbon)		8 000	465	450
Fatty acids (as C)		5 688	5	12
Ammoniacal-N		790	370	1 000
Oxidised-N		3	1	1.0
o-phosphate		0.73	1.4	1.0
Chloride		1 315	2 080	1 390
Sodium	(Na)	960	1 300	1 900
Magnesium	(Mg)	252	185	186
Potassium	(Kg)	780	590	570
Calcium	(Ca)	1 820	250	158
Manganese	(Mn)	27	2.1	0.05
Iron	(Fe)	540	23	2.0
Nickel	(Ni)	0.6	0.1	0.2
Copper	(Cu)	0.12	0.03	-
Zinc	(Zn)	21.5	0.4	0.5
Lead	(Pb)	0.40	0.14	-

(1) Recently-emplaced domestic wastes, in active "acid-forming" stage of anaerobic decomposition, with rapid production of readily-degradeable organic materials such as fatty acids.

(2) Relatively aged wastes in latter stages of stabilisation, containing a lower proportion of biodegradeable organic materials (as indicated by the low ratio of BOD:COD), but with continuing biogical activity as shown by the concentration of ammoniacal nitrogen.

(3) Leachate from rapidly-degrading domestic wastes, with active generation of methane, in water-saturated conditions. Low concentrations of volatile fatty acids indicate efficient conversion of these to landfill gases, and very high concentrations of ammoniacal nitrogen show a high rate of anaerobic biological activity with the landfill.

Copied from D.O.E. (U.K.) (1984)

4.2 Organic Contamination from Waste Disposal Sites.

There is increasing evidence of the presence of hazardous organic compounds in pollution plumes caused both by domestic tip sites and co-disposal sites. Skinner (pers. comm.) has found that leachates from domestic waste in England contained high COD levels and unidentified organics beneath sites with a thick unsaturated zone. According to Young (pers. comm.) there are indications that organic solvents are present in leachate from domestic waste sites. Investigations in North America are showing significant organic pollution of groundwater beneath municipal tip sites.

Reinhard etal (1984) have examined two municipal tip sites at Woolwich and North Bay in Ontario, Canada in great detail (at one site 62 bundle piezometers, each having 8-9 individual piezometers screened over short intervals were installed!). Both sites are on sand and gravel and both take domestic waste with small quantities of industrial waste. The Woolwich site has a thick (10-15m) unsaturated zone whereas the North Bay site has a thin (0-5m) unsaturated zone. The Woolwich site is 3.5 ha in extent, the North Bay site about 15 ha. This investigation showed that dissolved organic carbon (DOC) exists throughout the zones of contaminated groundwater which extended for over 600m from the Woolwich site and 800m to a spring from the North Bay site. Many toxic or potentially toxic compounds were found to be mobile in these groundwater systems. The main fraction of the DOC appeared to be derived from decomposing plant material (organic matter constitutes about 60% by dry weight of refuse (Anon, 1984)). Aliphatic and aromatic acids , phenols, resin acids and terpene compounds were the main components. Compounds of commercial or industrial origin were detected at both sites. Those included chlorinated benzenes, aromatic hydrocarbons, alkyl phosphates, alkylphenol ethoxylates and nitrogen-containing compounds. At the spring contaminated by the North Bay site the only inorganic pollutant was iron. Chloride had reduced to 50mg/l. But several organic contaminants were present in significant quantities which

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were volatilised on contact with air (Cherry, 1986). The authors (Reinhard etal., 1984) concluded that the leaching of phenolic and other potentially hazardous compounds from domestic landfills may well be a threat to many drinking water supplies.

4.3 Complications with Organic Contaminants.

4.3.1. Trace amounts of pollutants are difficult to measure and consequently analyses are expensive.

4.3.2 Many organic componds are of environmental significance in very low concentrations - parts per billion (ppb) or parts per trillion (ppt) quantities. Consequently very small amounts can cause severe pollution. For instance organic solvents are mobile and are a common groundwater contaminant in other developed countries. The Ontario drinking water limit for TCE (Trichoroethylene) is 10µg/l according to Cherry (1986). The quantity of solvent needed to bring the total quantity of groundwater used in Ireland - 34,000,000 m^3/yr - above this limit is 340 Kg. TCE is widely used to clean oil from industrial machines and to remove grease from clothes in dry cleaning. It is a confirmed animal carcinogen (Burmaster, 1982).

4.3.3 Even with modern analytical techniques, only organic compounds that comprise as much as 5 to 10 per cent of the DOC in zones of contaminated water at landfill sites are identifiable (Cherry et al., 1984)

4.3.4 The principal classes of chemical reactions that can affect organic contaminants in water are hydrolysis and oxidation, athough these reactions are slow unless the transformations are aided by microorganisms. However there is no assurance that the transformation of an organic solute will result in a harmless or less harmful product (Mackay et al., 1985). Biotransformation of common groundwater contaminants such as TCE, PCE (tetrachloroethylene) and TCA (1,1,1,-trichloroethane) can result in the formation of hazardous products such as vinyl chloride which is not transformed further in groundwater and is a confirmed human carc og n (Burmaster, 1982). Also, even if biotransformation products are less hazardous, they may be more mobile and create bigger problems (Schwarzenback, 1986).

4.3.5 Volatilisation is an important attenuating mechanism for many organic compounds in surface water and in the unsaturated zone. However it is not a factor in the saturated zone.

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4.3.6 Certain organic substances such as halogenated aliphatics, phenols and pesticides may degrade under anaerobic conditions but degrade only very slowly under aerobic conditions. In contrast, chlorobenzenes and alkyl benzenes degrade faster in aerobic conditions. This complicates prediction of attenuation.

4.3.7 Mackay et al. (1985) considered dispersion and retardation of Cl, TCE and PCE in an idealised sand and gravel aquifer which is 10m thick, a groundwater flow rate of 45m/yr. and a monitoring borehole 1km downgradient from the waste disposal site. These constituents should arrive after 22 years at the monitoring borehole if the groundwater flow rate is the only factor. However due to dispersion the Cl arrives after only 17 years while the TCE arrives after 35 years and the PCE after 50 years due to the effect of retardation. This example indicates that the presence of Cl and the absence of organic compunds in a monitoring borehole is no indication that the organic contaminants will not reach the borehole at a later date.

4.3.8 Chloride or other conservative inorganic substances are not adequate indicators of organic contaminant presence or distribution although they can provide qualitative identification of major zones of contamination (MacKay etal, 1985). Reinhard et al. (1984) showed that Cl, DOC and xylenes were concentrated in the centre and upper sections of leachate plumes whereas benzoic acid, phenols and TCE were at the bottom. Consequently the contaminated zone must be regarded as a multiplicity of plumes.

4.4 Health Risks of Contaminants

According to Pettyjohn and Hounslow (1983) "the longterm health effects brought about by consumption of low levels of organic contaminants over a long time period are simply unknown, or based on speculation or educated guesses." Newsom (1985) points out that the health risks are difficult to determine, mainly because of the uncertainty in extrapolating the results of laboratory carcinogen tests to humans. Fielding et al. (1981) admit that there is controversy regarding the presence or absence of a no-effect level, particularly for carcinogens. They maintain that there is evidence from animal experiments and occupational exposure data to indicate that repeated small doses of some organic chemicals may lead to chronic toxic effects, and consequently without evidence to the contrary, the presence of low level organic compounds in water cannot be dismissed as insignificant.

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4.5 Implications for Ireland

Due to our lower level of industrial and agricultural development and our lower population density, the problems that are becoming apparent in other developed countries should not be present to the same degree here. However we must learn from the findings and mistakes made in other countries. Consequently the situation regarding potential organic pollutants should be reviewed. Monitoring of groundwater for organic contaminants should commence. Laboratory analytical facilities for a broad range of contaminants should be made available. The potential of pollution from domestic and co-disposal tip sites has increased in view of these findings and consequently this should be taken into account in site selection.

5. SITE SIZE

Many local authorities are still operating small (less than 50 tonnes/week) poorly-managed sites for the disposal of domestic refuse. The main reason, presumeably, is to save on transport costs. It is difficult to assess the effects of these sites on water as they have not been examined in any detail. There is some evidence to suggest that the effects are small because their size and scattered location disperses the polluting effects. However small sites have the following disadvantages:

1. It is not cost-effective to engineer and operate these sites with adequate labour and equipment so that environmental effects are minimised. Consequently they are usually eye-sores with litter, fires, vermin and birds common problems. They result in strong community reaction against new tip sites, including planned, properly investigated, sited, designed and operated sites. They give a bad example to the local community and give other polluters an excuse.

2. It is not possible to justify the cost of proper site investigation. Consequently the adverse environmental effects cannot be predicted.

3. As they are usually not adequately staffed, illegal tipping of hazardous waste can occur.

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Consequently it is desirable that local authorities should reduce the number of small sites as much as practicable and concentrate on a number of properly sited, designed and operated sites which could also be used for the disposal of certain industrial wastes.

6. CO-DISPOSAL SITES

These are considered in more detail in the paper by Daly (1983) which can be obtained on request from the Geological Survey.

Co-disposal sites are those where small quantities of certain industrial wastes, including some hazardous wastes, are deposited with domestic waste. The decomposing domestic waste acts like a chemical and biological treatment plant on the industrial wastes, bringing about attenuation. In this way the potential polluting load of the industrial waste is reduced. Research and investigations carried out mainly in England have shown that co-disposal with domestic waste is a relatively cheap and environmentally safe method of disposing of certain industrial wastes.

According to the Department of Environment Circular Env 10/82, co-disposal of industrial wastes should not significantly increase the quantity or worsen the quality of the leachate from domestic waste. Consequently co-disposal is not applicable to all industrial wastes and before an industrial waste is deposited the local authority must ensure that co-disposal is the proper disposal option.

Should co-disposal sites be considered in a different manner to sites with domestic waste only? Firstly, it is now apparent that domestic waste produces a leachate which contains significant quantities of dangerous organic substances. Secondly, industrial wastes such as metal sludges are generally not very mobile in a properly located and operated site and should not cause significant pollution problems. Thirdly hazardous organic wastes should not be allowed on a co-disposal site. Consequently the leachate from a co-disposal site should be no worse than that from a domestic waste site. In any case this is the Department of Environment requirement. This implies that co-disposal sites and domestic waste only sites need not be considered differently. It could be argued that a difference between the two is that there is a higher risk of problems from co-disposal sites. However this depends largely on correct operation of co-disposal sites.

It is recommended that the standards of investigation, design and operation of co-disposal sites should also apply to domestic waste sites.

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7. PREVENTION OF POLLUTION FROM WASTE DISPOSAL SITES

7.1 Introduction

The potential adverse environmental effects of waste disposal are largely avoidable. Success in minimising or preventing these effects depends on careful location, design and management of the sites following a detailed site investigation. Success also depends on adequate financing and the availability of trained professional and technical staff. A change of attitude is needed in some local authorities. Firstly, waste disposal has too low a priority when finances are being allocated. Secondly, the disposal of waste should be considered a technical challenge, similar to the building of other engineering projects.

Many of the topics appropriate to this section are dealt with in the geotechnical guidelines (Daly and Wright 1982). Consequently, only certain aspects such as environmental standards, the planned approach to waste disposal, and the location of optimum sites are covered in this paper.

7.2 Environmental Standards

In order to set about preventing pollution, it is helpful if the statutory authorities - the local authorities, Department of Environment, An Bord Pleanala, etc - have a clear view on the environmental standards they wish to maintain. There is frequent talk of "acceptable levels of pollution" yet this concept is not clear to me. It seems to vary with the philosophy of the person using it as a reason or excuse for allowing contaminants into water. On other occasions practical problems such as lack of finance result in the acceptance of high pollution levels. Groundwater contamination has resulted from technological development which has benefited society in many ways but has also created some risks. I suggest that more emphasis should be given to risk assessment when considering potentially polluting developments such as waste disposal sites. Admittedly this is not easy because there may not be sufficient knowledge to allow accurate predictions, particularly with regard to organic contaminants. As pointed out by Haimes (1984) the dilemma is whether to a) wait for additional information, thus avoiding potentially unnecessary cost but risking adverse consequences that might be irreversible, or b) take costly preventative actions which might prove later to have been unnecessary.

Does legislation such as the Local Government (Water Pollution Act) 1977 or the E.C. directives provide us with environmental standards? According to the E.C. Groundwater Directive (1982) the substances that are prohibited from entering

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groundwater include organohalogen compunds, organophosphorus compounds and substances which possess carcinogenic, mutagenic or teratogenic properties in the aquatic environment. In this directive water in undeveloped aquifers is protected as if it were developed (Anon 1984). Consequently the volume and planned future use of an aquifer are no longer factors for consideration in reaching a decision about allowing a waste disposal site (Anon 1984). In view of the recent findings with regard to organic contaminants, the groundwater directive implies that both domestic and co-disposal sites should only be located where pollutants can be prevented from entering aquifers. This would rule out unlined sand and gravel quarries. The directive would also prevent local authorities from saying that they are willing to contaminate an aquifer by choice in order to find a tip site.

It this interpretation correct? It is reasonable? It ist enforceable? Could groups who oppose sites use the Directive to prevent their location?

With regard to waste disposal sites, Cartwright (1984) has proposed that a performance standard should be stipulated for the maximum effects sites can be allowed to have on surrounding land uses, including water, which would specify the water quality criteria and the volume and concentration of contaminants allowed to discharge from the landfill. The performance standard could be a statement specifying drinking water standards. He suggests that the standard should clearly specify the area at which the criteria for water quality are to be applied (such as at the property line or the nearest aquifer or body of surface water). If a mixing zone is acceptable, than the performance standard should specify the size of the zone. He maintains that specifications must be realistic because specifying that there must be "zero discharge" immediately adjacent to the waste is not realistic. This proposal is interesting and seems reasonable but there are problems with it:

1. It may be easy to apply it to surface water but it is less satisfactory for groundwater because it assumes that the effects of leachate on an aquifer can be predicted accurately in advance.
2. Unless the performance standard is set by a body removed from local pressures, the standard may be very low.
3. It might contravene the EEC directives.

Some scientists and engineers maintain that the controv sy over pollutants such as trace organics and their possible carcinogenic effects is paranoia and hysteria brought about by impractical academics and extremist environmentalists.

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Some scientists also maintain that the maximum acceptable limits for some pollutants are too low and impracticable. Others believe that dilution solves most pollution problems.

In my opinion there is little point in engineers and hydrogeologists complaining about the maximum acceptable limits for pollutants as we have neither the authority or competence to change them. Consequently we should endeavour to main water quality below these limits. I suggest that dilution is a short term solution to disposal of pollutants, particularly in the Irish situation where all our aquifers, with the exception of sand and gravel, have low storativity. It may seem reasonable for a local authority to decide to allow pollution of a minor aquifer and forfeit its use as a source of water. Yet this could contravene an EC directive and in view of the difficulty in predicting pollution effects from a waste disposal site, there are dangers with this approach.

7.3 A Planned Approach to the Location of Tip Sites

[This section is taken largely from Daly (1983)]

Locating tip sites, whether for domestic waste alone or for co-disposal, can be time-consuming, difficult and expensive for local authorities. Difficulties arise particularly due to public resistance to sites in their area and the present financial restrictions Because of these problems, sites are often bought without investigation simply because they are available. Site investigations cost substantial sums and consequently it is important not to waste time and money on unsuitable sites. Problem sites can be engineered (e.g. an artificial liner might be used) and operated so that environmental effects are minimised, but this can be costly. Also, the risks from highly engineered problem sites are usually greater than from good natural sites. The presence of cover material at or close to a site simplifies and reduces the cost of operating the site. Consequently, locating geologically and hydrogeologically optimum sites has many benefits for local authorities. It even helps those local authorities who are unwilling or unable to locate and run proper sites by limiting their poorly run sites to areas where pollution, if not prevented, is at least minimised by the natural situation.

Optimum sites can be chosen by a local authority if there is sufficient geological and hydrogeological information compiled as maps. The following maps are required:

1. Bedrock geology;
2. Surficial geology (Quaternary deposits):

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3. Depth to bedrock;
4. Aquifer maps with a synopsis of hydrogeological data;
5. Aquifer protection or aquifer vulnerability maps.

By superimposing various maps on one another, optimum areas can be located, for instance, areas with thick boulder clay overlying a low permeability bedrock, areas with clayey gravels and a thick unsaturated zone, or areas where the groundwater is saline and unpotable. By identifying these areas, inappropriate site investigations and expensive engineering solutions and operational methods can be avoided. Obviously there are also non-geological factors to be considered, such as distances from the waste source, and cost and difficulty of acquisition, which are important. But this approach allows comparison of the different areas including consideration of non-geological factors, and allows the best potential site or sites to be chosen, thereby benefitting both the environment and the local authority finances. This approach also has another major advantage for local authorities: when asked the difficult question "why this site? why not some other area?" the local authority can state that the site is in one of the optimum hydrogeological areas and that the whole county or a large area has been examined.

One difficulty at present is that for some counties or parts of counties the available geological and hydrogeological data are sparse and this approach is only as good as the available data. However, this can be overcome if local authority engineers collect and compile geological and hydrogeological data in the course of their work.

Although this planned approach to the location of tip sites has been urged on local authorities for several years, very few have adopted it so far.

7.4 Optimum Site Characteristics

A useful classification of tip sites is one based on hydrogeological characteristics. This classification depends on the degree and type of permeability of the underlying rocks and on the depth to the water table. The topographic situation is also important (see Daly and Wright (1982) and Daly 1983 for further details).

There are 4 hydrogeological site types:

1. Containment sites where the leachate is prevented from migrating away from the site into groundwater or surface water by surrounding low permeability rocks such as boulder clay or peat or an artificial liner.

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2. Slow migration sites with a thick unsaturated zone. These sites are on sands and gravels. They are "dilute and disperse" type sites where the leachate is attenuated as it moves through the unsaturated zone.
3. Slow migration sites with little or no unsaturated zone. These are usually sand and gravel quarries
4. Sites allowing rapid migration. These are present on fissured rocks such as limestones and sandstones and are only suitable for inert wastes.

Slow migration sites with a thick unsaturated zone are theoretically the most favourable sites because the natural processes within and beneath the site treat and attenuate the leachate. They are commonly used in England, although they are far less common in other developed countries. Opinions on the suitability of these sites among British scientists and engineers seems to be changing. Insufficient attenuation has been found beneath some sites in the Bunter Sandstone and consequently it is believed that "dilute and disperse" sites will become rarer in the future, particularly in the higher rainfall areas.

In Ireland the only aquifer with an intergranular permeability are sands and gravels. With present knowledge it is not possible to rule out this type of site in Ireland, but good sites are likely to be few in number and difficult to locate. Also, in view of the uncertainties about attenuation in the unsaturated zone, their suitability is in doubt.

Slow migration sites with little or no unsaturated zone are not suitable for the disposal of domestic or noxious industrial wastes unless they are lined with an impermeable liner, or the local authority is willing to allow pollution and risk the potential effects. Consequently, the present trend of some local authorities towards concentrating on sand and gravel quarries is not recommended.

The optimum area for a site in most local authority areas is considered to be a greenfield site underlain by thick boulder clay which in turn is underlain by low permeability bedrock. The boulder clay can be excavated and used for intermediate and top cover and for building bunds. A consequence of this type of site is that the leachate must be collected and disposed of. This type of site allows control of the leachate and does not depend on the unpredictable attenuating processes in aquifers which may not be adequate to prevent pollution. The Collon site in County Louth is a good example of this type of site.

The present emphasis of local authorities on looking for "holes" or quarries to fill in should be discontinued. They are often unsuitable and require costly

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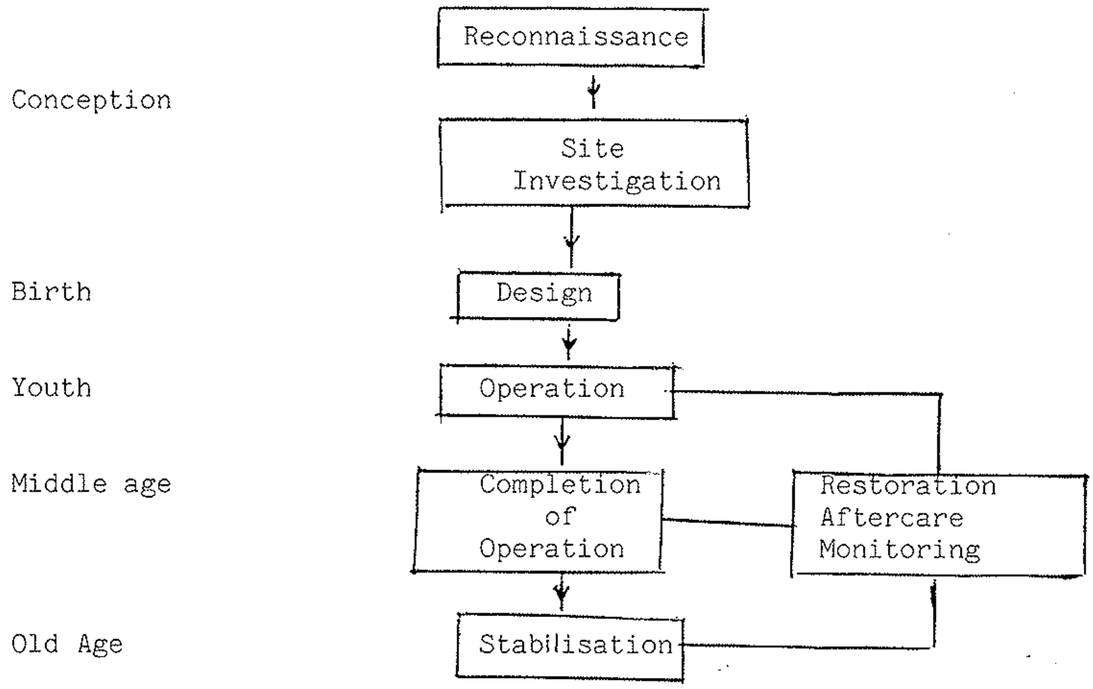
engineering works if pollution is to be prevented. (The term "landfill" is not used in this paper because of the implications of the term).

7.5 Site Investigation, Design and Management

The life of a landfill can be subdivided into a series of logical progressive stages as shown below:

STAGES OF THE LIFE OF A TIP SITE



(adapted from Aspinwall et al. (1984) and Aspinwall (1986))

At each stage a primary objective must be prevention of adverse environmental effects. However, nuisance can only be avoided if sufficient finances are available for adequate expertise and capital expenditure (Aspinwall et al 1984) Local authorities must consider the running of a waste site as a substantial investment over the life of the site (perhaps 20-30 years). In view of this investment , it is vital that local authorities should be able to project the likely requirements for capital investments and operational costs, for the preparation, operation and maintenance of the site to adequate environmental standards. Papers by Aspinwall et al (1984) and Johnston (1983) allow rapid and low cost financial analyses of sites, and the system outlined in those papers is recommended for use by local authorities.

Aspinwall et al (1984) evaluated the costs involved in completing the various stages in the life cycle of a landfill for four theoretical sites. These are expressed as percentages below:

	Range of % costs	Mean
Site Assessment	0.3 - 1.0	0.7
Development	4.3 - 12.4	7.2
Acquisition	6.9 - 17.8	12.8
Operational costs	70.7 - 75.4	72.9
Restoration costs	1.8 - 8.3	4.2
Aftercare	0.8 - 4.1	2.2

It is emphasised that the standards applied in this study are "defensible" and are not unattainably high standards. Such standards should be applied in Ireland. Several interesting points arise from the above table:

1. The site assessment costs (which include the site investigations) are generally less than 1% of the total cost, yet this is a crucial stage. Most of the environmental problems associated with tip sites have been created by an incomplete understanding of the site due to lack of detailed consideration at this stage (Aspinwall et al 1984). This stage allows prediction of the likely effects on the environment, and based on these predictions the local authority can then make an informed decision. Consequently local authorities must be willing to finance this stage properly. In Ireland the site assessment stage is likely to cost £20,000-£30,000.
2. Operational costs are by far the major proportion (over 70%) of total costs.
3. The costs of restoration and aftercare, which play a vital part in influencing public reaction to and acceptability of tip sites, are only about 6% of the total costs.

7.6 Professional and Specialist Expertise

A modern waste disposal site is a complex, specialised project requiring a broad range of professional disciplines - civil engineers, mechanical engineers, water treatment engineers, geologists, hydrogeologist, chemists, planners, landscape architects, etc. In Ireland we are at an early stage in acquiring this expertise, understandably because until recently it was not required. For some time to come the expertise available in Ireland will need to be supplemented by overseas consultants in various disciplines.

In order to achieve self-sufficiency on the longer term it is suggested that Irish consultants should link up with overseas consultants to provide the full range of required expertise to local authorities. Eventually indigenous expertise should be able to take over completely from the overseas consultants.

It is also recommended that more emphasis should be given to solid waste management in our Universities and technical colleges. Overseas visits by professionals in the field are also important in widening and deepening experience.

8. CONCLUSIONS

8.1 Local Authorities should take a long-term planned approach to site selection to enable them to locate optimum sites.

8.2 Waste disposal sites should be selected, designed and managed to standards which generally prevail in other developed countries. Emphasis should be on adequate, defensible environmental standards and not on least-cost standards.

8.3 Greater consideration should be given to the possibility of pollution from trace organics both from domestic waste sites and co-disposal sites. Although there is debate on the health hazard of organics, a cautious approach is recommended because the effects do not become apparent immediately.

8.4 There should be less emphasis on small sites and local authorities should concentrate on large (greater than 200 tonnes/week) sites which are properly selected and operated.

8.5 Co-disposal sites and domestic waste only sites should be considered to have equal potential to cause pollution and consequently should not be considered differently during the selection process.

8.6 Slow migration sites with a thick unsaturated zone should be treated with caution as the attenuating ability of this zone is now in doubt.

8.7 Gravel pits where the water table is close to the quarry bottom should only be used for inert waste and not for domestic or industrial waste unless the site is engineered to prevent leachate migration.

8.8 Local authorities should place less emphasis on looking for "holes" to use as tip sites.

8.9 The optimum area for a site is considered to be a greenfield site on thick boulder clay.

8.10 If adverse environmental effects from tip sites are to be minimised, adequate financial resources must be made available.

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8.11 There is a need for a multi -disciplinary professional review of present and future waste disposal practice in Ireland in the light of current research and practice worldwide. The best way to carry out this review might be the formation of a working group of representatives from the various professional desciplines involved, convened by the Department of the Environment. The objectives of the group would be:

1. to review present waste disposal practice in Ireland;
2. to commission investigations of representative existing tip sites to assess their environmental effects;
3. to assess the research, experience and practices of other developed countries and to apply them to Ireland;
4. to consider other environmental aspects as well as water pollution;
5. to consider feasible environmental standards;
6. to review the geotechnical guidelines;

8.12 It is clear that, even where authorities adhere to the best possible standards and practices in planning, site selection, operation and management, there will continue to be great difficulties in acquiring sites. It is up to the professional community: firstly to demonstrate that their standards of selection and operation of sites are scientifically defensible, secondly to make clear to the community that such standards are necessary and have to be paid for, and thirdly to demand from the legislature adequate powers to investigate and acquire optimum sites with fair compensation.

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DEVELOPMENT OF AN EXTENSION TO

THE LANDFILL TIP

AT

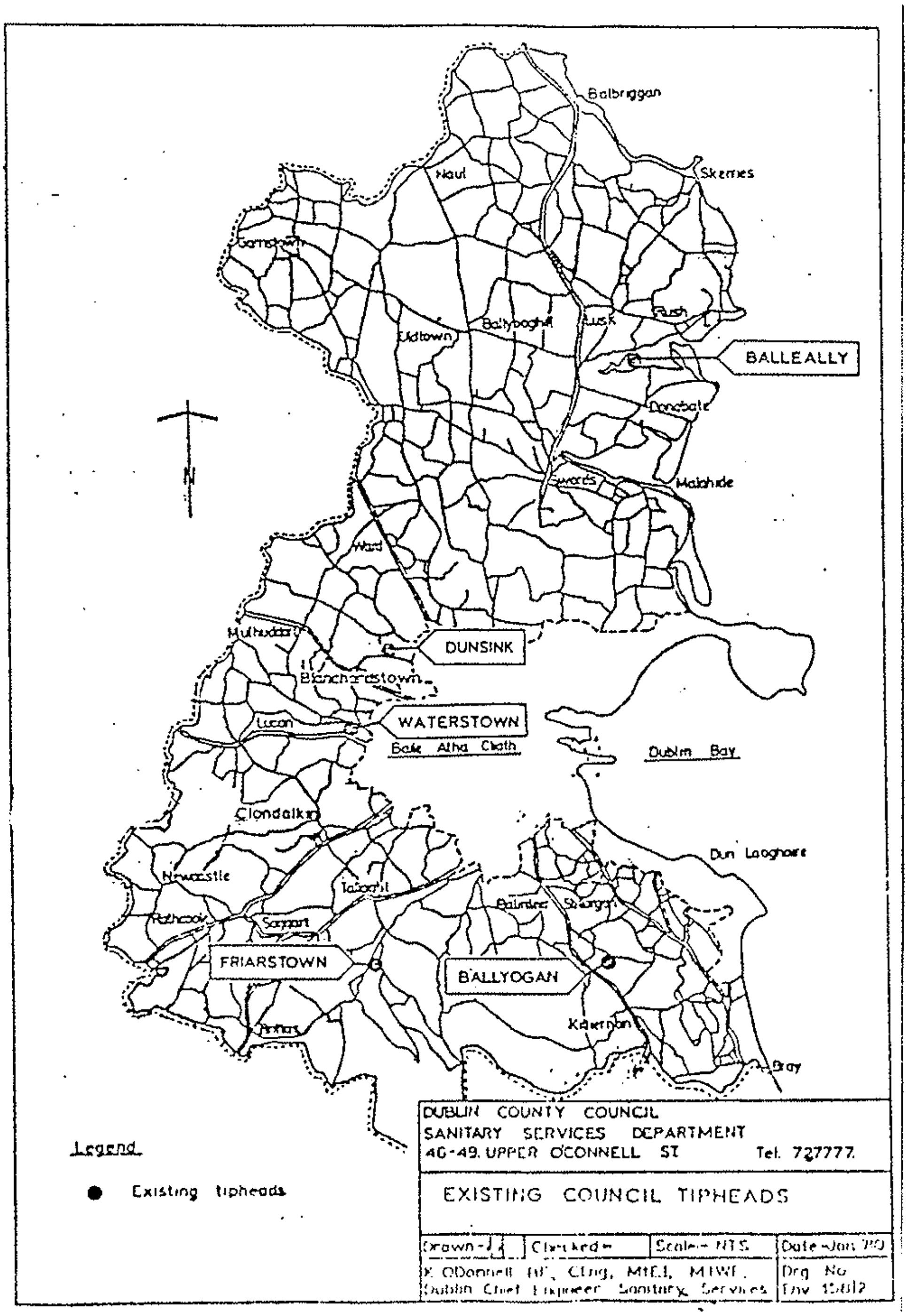
BALLYOGAN, CO. DUBLIN

MARCH, 1986.

Michael Lorigan,
Executive Engineer,
Environment Section,
Dublin County Council.

1. INTRODUCTION:

All domestic waste generated by Dublin City and County is disposed of in landfill sites developed and operated by Dublin County Council. Five landfill sites are being used at present (see Drg. No. 158/2) to cater for an annual input of 317,500 tonnes of domestic refuse and an additional 140,000 tonnes of waste from other sources (see Table 1 for breakdown).



1985 WASTE INTO DUBLIN COUNTY COUNCIL TIPHEADS

SOURCE	BALLEALLY	DUNSINK	WATERSTOWN	BALLYOGAN	FRIARSTOWN	TOTAL
DOMESTIC REFUSE						
Dublin County Council	29 000	15 000	—	36 500	44 000	124 500
Dublin Corporation	—	165 500	—	8 000	—	173 500
Dun Laoghaire Corp.	—	—	—	19 500	—	19 500
Total	29 000	180 500	—	64 000	44 000	317 500
MAINTENANCE & STREET CLEANING						
Dublin County Council	8 500	2 000	—	1 500	11 000	23 000
Dublin Corporation	1 500	19 500	—	1 000	—	22 000
Dun Laoghaire Corp.	—	—	—	2 000	—	2 000
Total	10 000	21 500	—	4 500	11 000	47 000
TRADE WASTE INCL. AGRICULTURAL	22 000	—	29 000	—	—	51 000
PRIVATE CARS & VANS	2 500	20 000	—	14 500	10 000	47 000
TOTAL	63 500	222 000	29 000	83 000	65 000	462 500

NOTE:
All figures in tonnes

As part of an extensive survey of South County Dublin for future suitable landfill sites the areas adjoining Ballyogan Tiphead were considered. Preliminary indications were that an area adjoining the tiphead of some 75 acres (49.14 ha) could be developed at a reasonable cost for the tipping capacity yielded and the proposed infill would not detract from the amenity value of the area. On this basis the Council commissioned Dr. K. Cullen to carry out a full hydrological and hydrogeological survey of the lands and surrounding area with the aid of a trenching and drilling programme.

2. RESULTS OF HYDROLOGICAL AND HYDROGEOLOGICAL STUDY:

The results are that the lands are underlain by a blanket of glacial tills ranging in thickness from 7.3m to 14.5m. Granite bedrock underlies the whole Ballyogan area with a permeability of 10^{-6} to 10^{-7} M/sec.

The area itself has little groundwater potential and the only steps required are to protect the amenity value of any streams in the locality.

The glacial tills consist of sands and gravels in one part of the site and unconsolidated boulder clays with a permeability of 10^{-7} to 10^{-8} m/sec. in the rest of the site. There is a shallow water table between 2m and 3m deep over the site but there is no evidence of any springs.

3. TIPPING CAPACITY:

Reference to Drawing Nos. 1, 2A and 2B will show typical cross sections of the original lands and proposed final levels once tipping is completed. The shallow water table means that in most places the topsoil only can be taken off the land prior to tipping taking place. This reduces the tipping capacity of the site to approximately one million cubic metres of domestic refuse allowing for the cover material required.

A general rule of thumb is that one tonne compacted of domestic refuse occupies a cubic metre volume.

4. DEVELOPMENT OF LANDS:

(a) Leachate Control:

The lands at Ballyogan have been developed for tipping on the basis that all leachate generated is contained within the site and diverted to the combined sewer at Brigton Road, Foxrock. This system is overloaded at times of heavy rainfall so storage lagoons are used to reduce the demand on the system when required (see Drg. No.4).

While the unconsolidated boulder clays in the site investigated are a suitable host material for a containment site; the sands and gravels are not. That area will be lined with a High Density Polyethylene Liner (e.g. 2.5mm Schlegal sheeting) and will double up as an effective storage lagoon in the future.

Leachate drains are laid at the perimeters of the site and in a herring bone pattern throughout the site. They consist of 225mm dia. OGEE pipes wrapped in a filter fabric e.g. 700 gauge Terran) and bedded and surrounded in 12mm pea gravel.

(b) SURFACE WATER CONTROL:

Measures have been taken to divert all streams and surface water drains away from the tipping area to minimise the volumes of leachate generated (see Drg. Nos. 3A & 3B). The result is that direct precipitation only on the tipping area will be generating leachate. An effective clay cap used as final cover will reduce the volumes generated to manageable levels.

(c) METHANE GAS:

In view of the intention to cap the tipped area with an "impermeable" clay cap a venting system will be installed to disperse any methane gas generated.

Manholes are not normally used when constructing the leachate collection system because of the presence of methane gas. Any manholes installed are fully vented.

(d) COVER MATERIAL:

One of the major advantages of a landfill site on the outskirts of the city is a plentiful supply of cover material from construction work which is delivered free of charge.

Apart from the volume of clay required for a metre deep final capping (200mm topsoil and 800mm subsoil) approximately 10-15% intermediate cover material vs volume of refuse deposited is used. This arises from the Council's strict adherence to the policy of covering all domestic refuse no later than the end of the day on which it is tipped.

(e) TIPPING IN CELLS:

Tipping operations are carried out in cells surrounded by bund walls. Paper screens are erected on top of these bund walls using 4,500mm high forestry poles with chainlink fencing attached all of which can be dismantled and reused. Typical capacity developed would be for a year at a time.

Seperate provision is made for cars. This consists of a fenced hardstanding area This facility can be developed with several years capacity but it should be within easy distance of the main tipping operation so that machinery can be used effectively.

The prevailing winds in the Ballyogan area are South Westerly so the tipfaces developed allow the freighters to tip in the downwind direction. The new lands are quite well sheltered by trees and this helps keep down windblown papers particularly in the car tipping area.

(f) ACCESS AND CONTROL:

Entry to the new extension is via the access to the original tip (see Drg. No. 1).

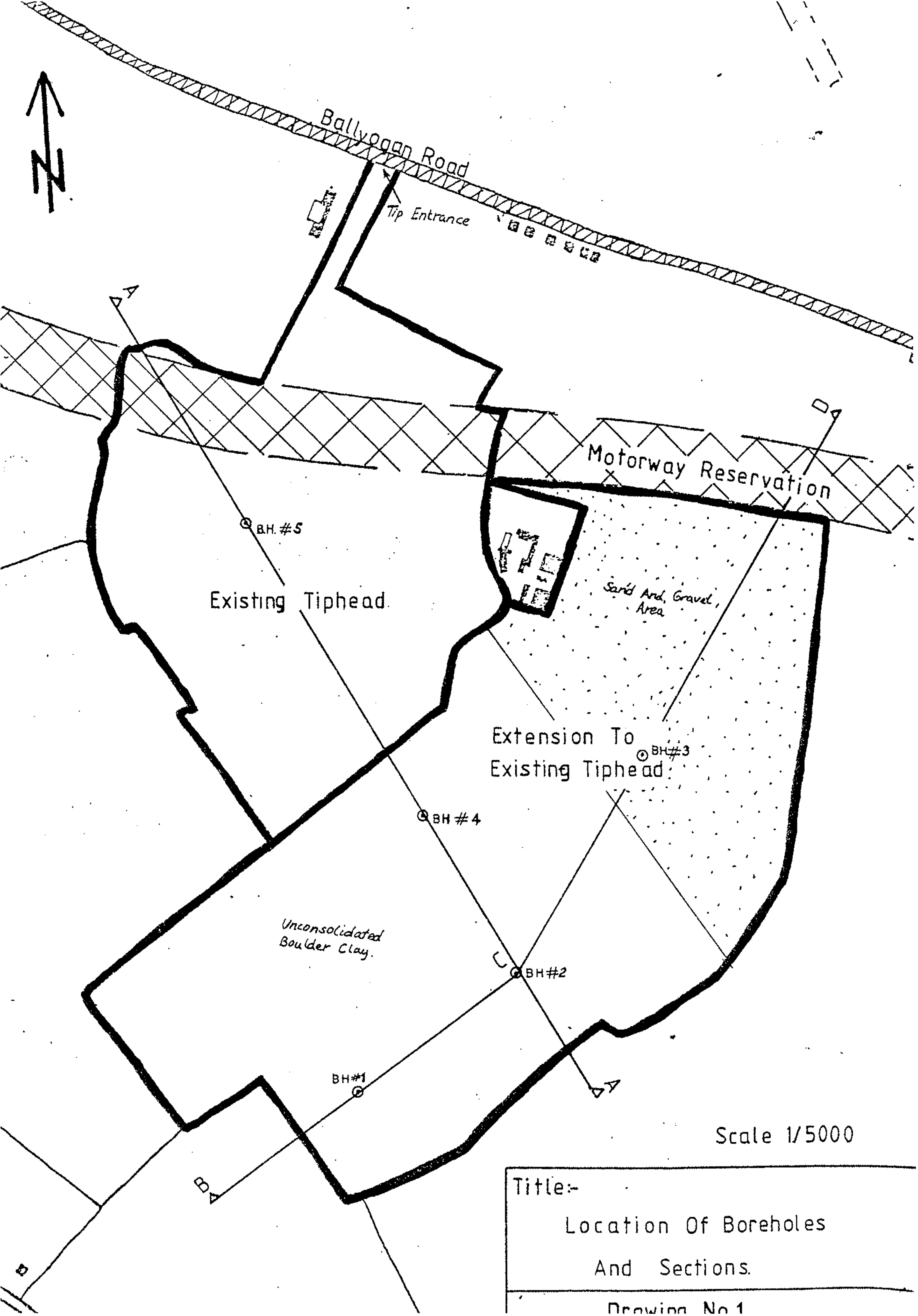
Refuse vehicles entering are recorded on a weighbridge. This is useful from the point of view that regular surveys of the landfill tip can establish the compaction being achieved. A weighbridge is also the most effective means of establishing a fair pricing structure for taking in commercial waste for disposal.

When leaving the vehicles pass through a purpose built wheelwash.

5. FINAL COMMENT:

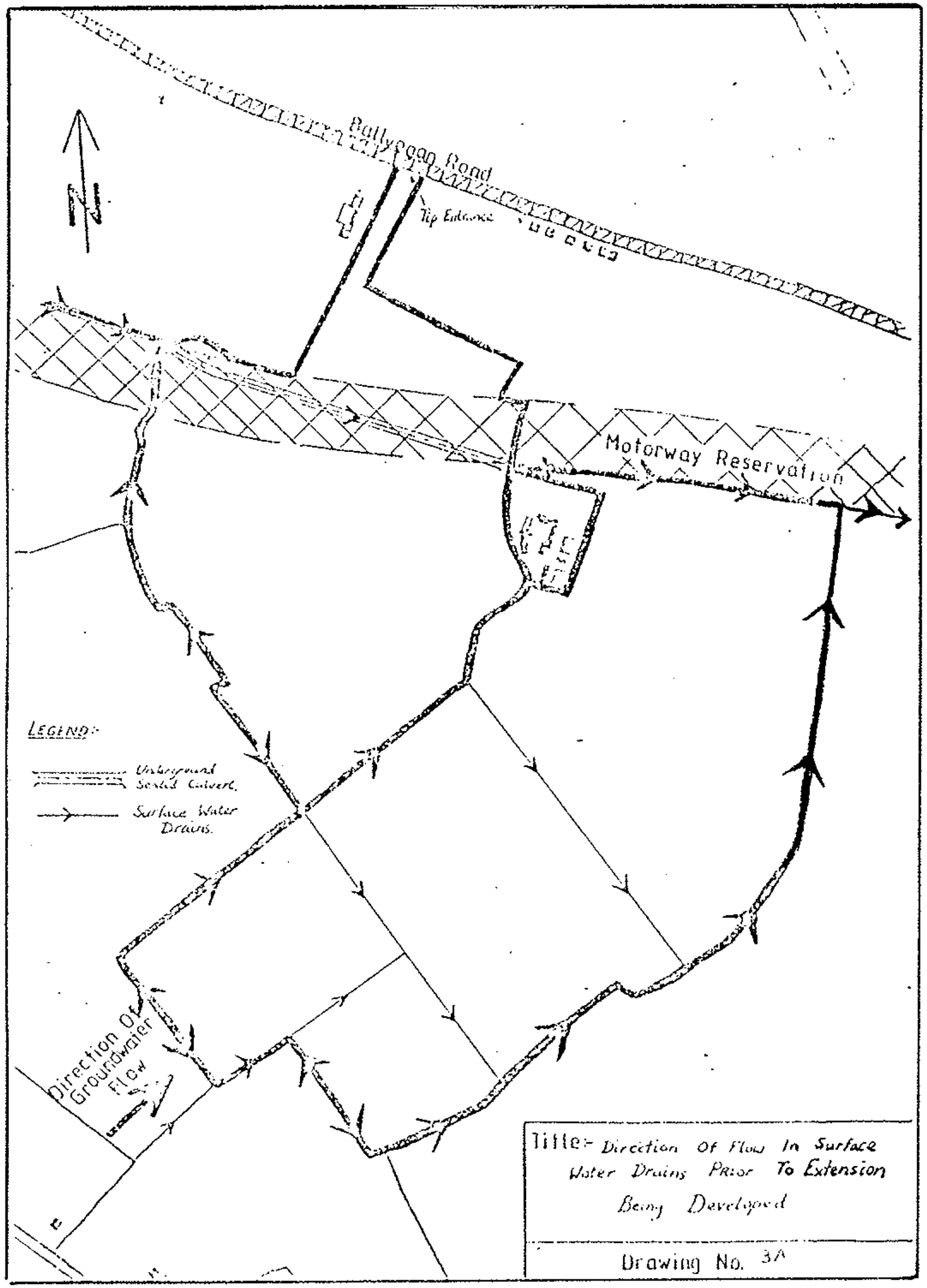
The reinstated lands will eventually be used as the second nine holes of the existing public course at Stepaside.

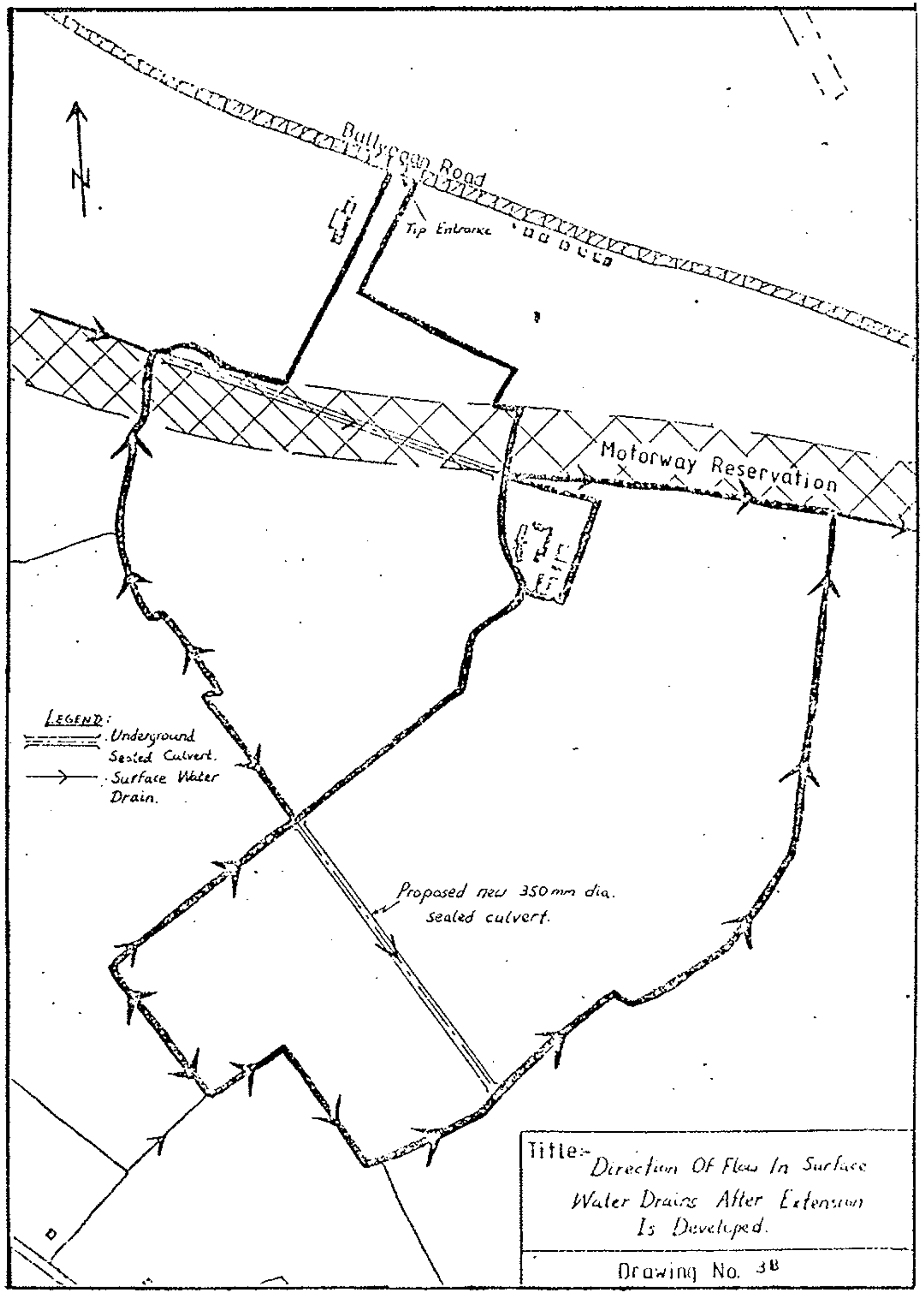
This will achieve the general objective of Dublin County Council; providing suitable lands for developing a landfill tip and justifying expenditure on an amenity sought after in the area.While it would never be denied that the end result will be worthwhile the Council are endeavouring to operate the landfill site to ensure that the transition is as painless as possible.

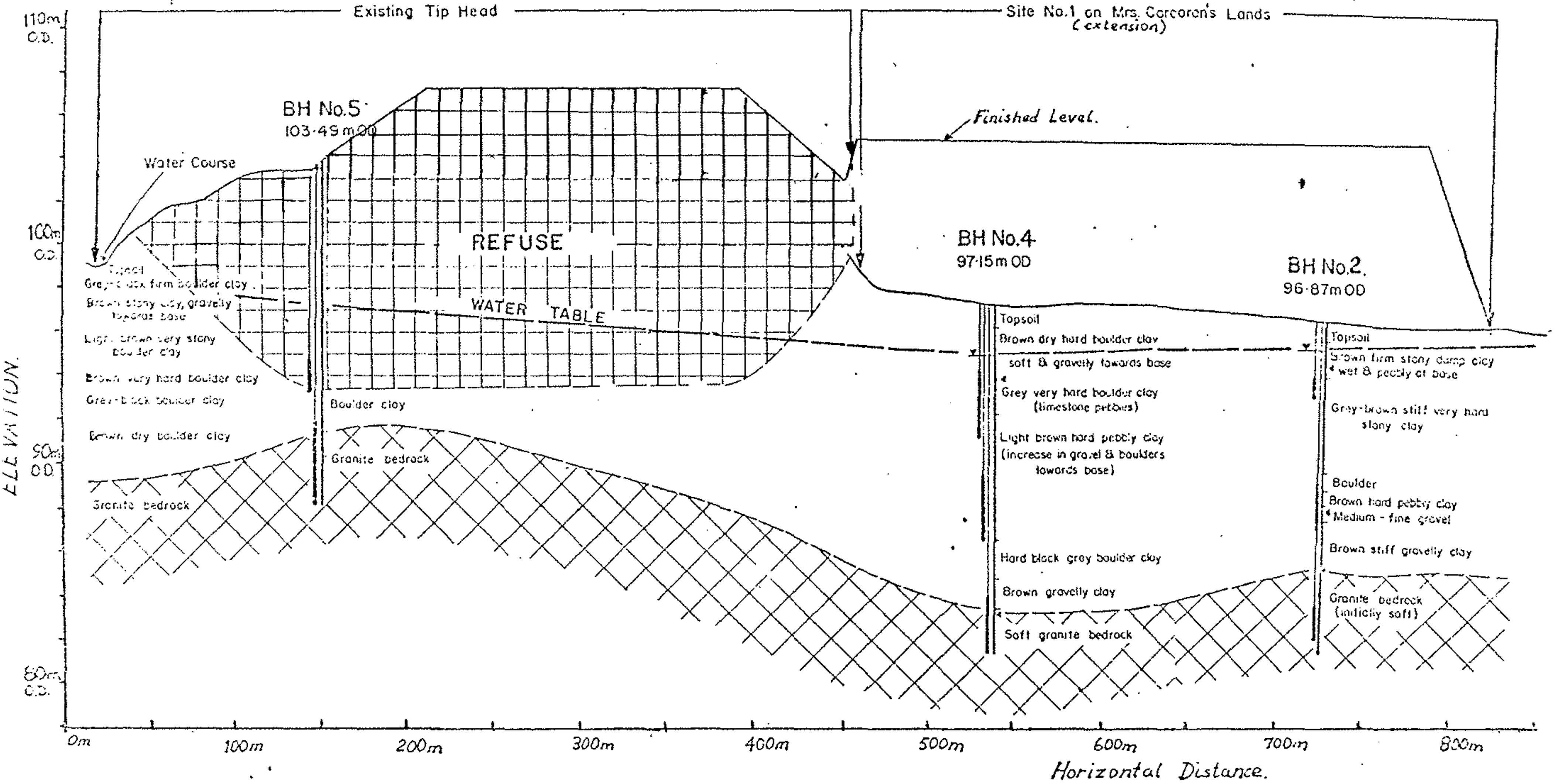


Title:- Location Of Boreholes And Sections.

Drawing No.1

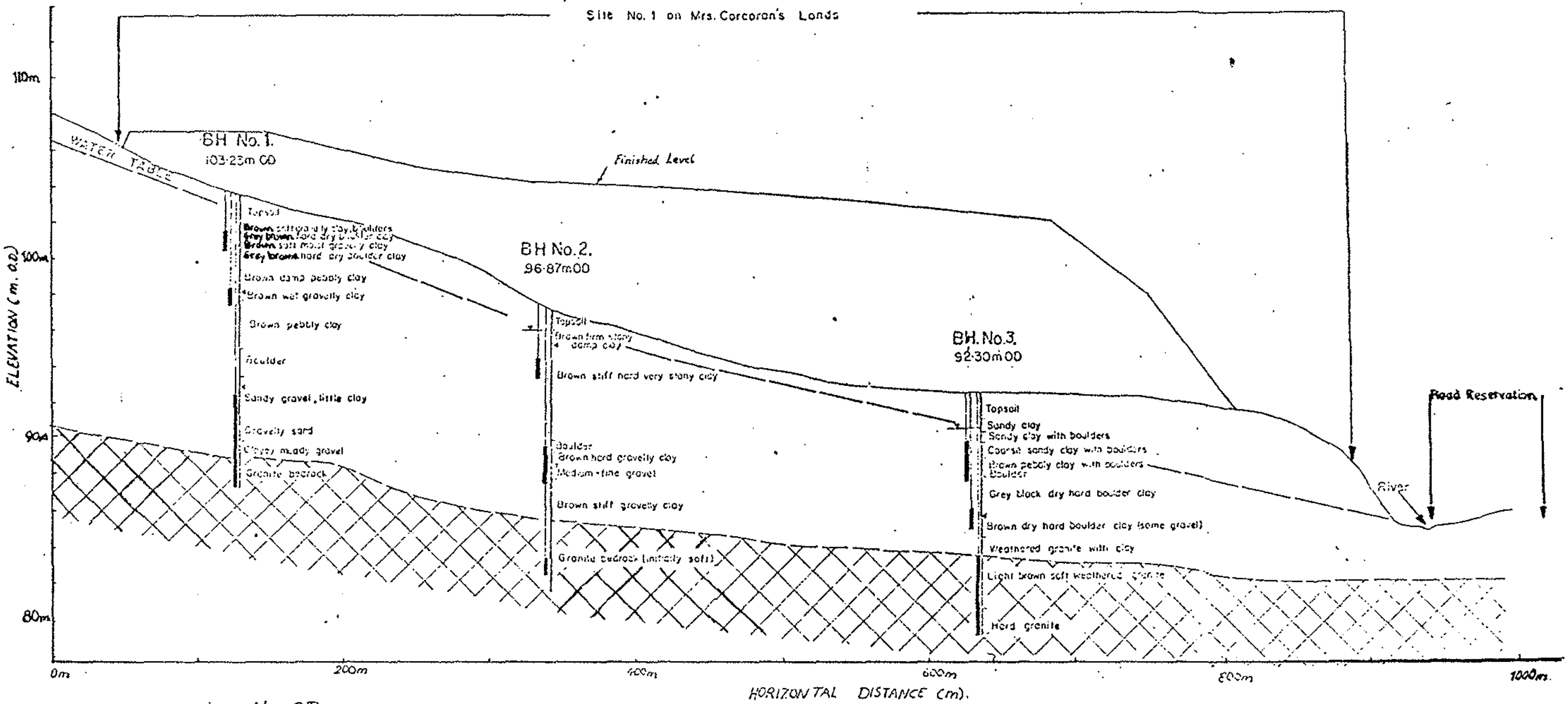

Ballycoan Road
N
Tip Entrance
Motorway Reservation
LEGEND:-
Underground Sealed Culvert.
Surface Water Drains.
Direction Of Groundwater Flow
Title:- Direction Of Flow In Surface Water Drains Prior To Extension Being Developed
Drawing No. 3A


Ballycoan Road
N
Tip Entrance
Motorway Reservation
LEGEND:
Underground Sealed Culvert.
Surface Water Drain.
Proposed new 350mm dia. sealed culvert.
Title:- Direction Of Flow In Surface Water Drains After Extension Is Developed.
Drawing No. 3B



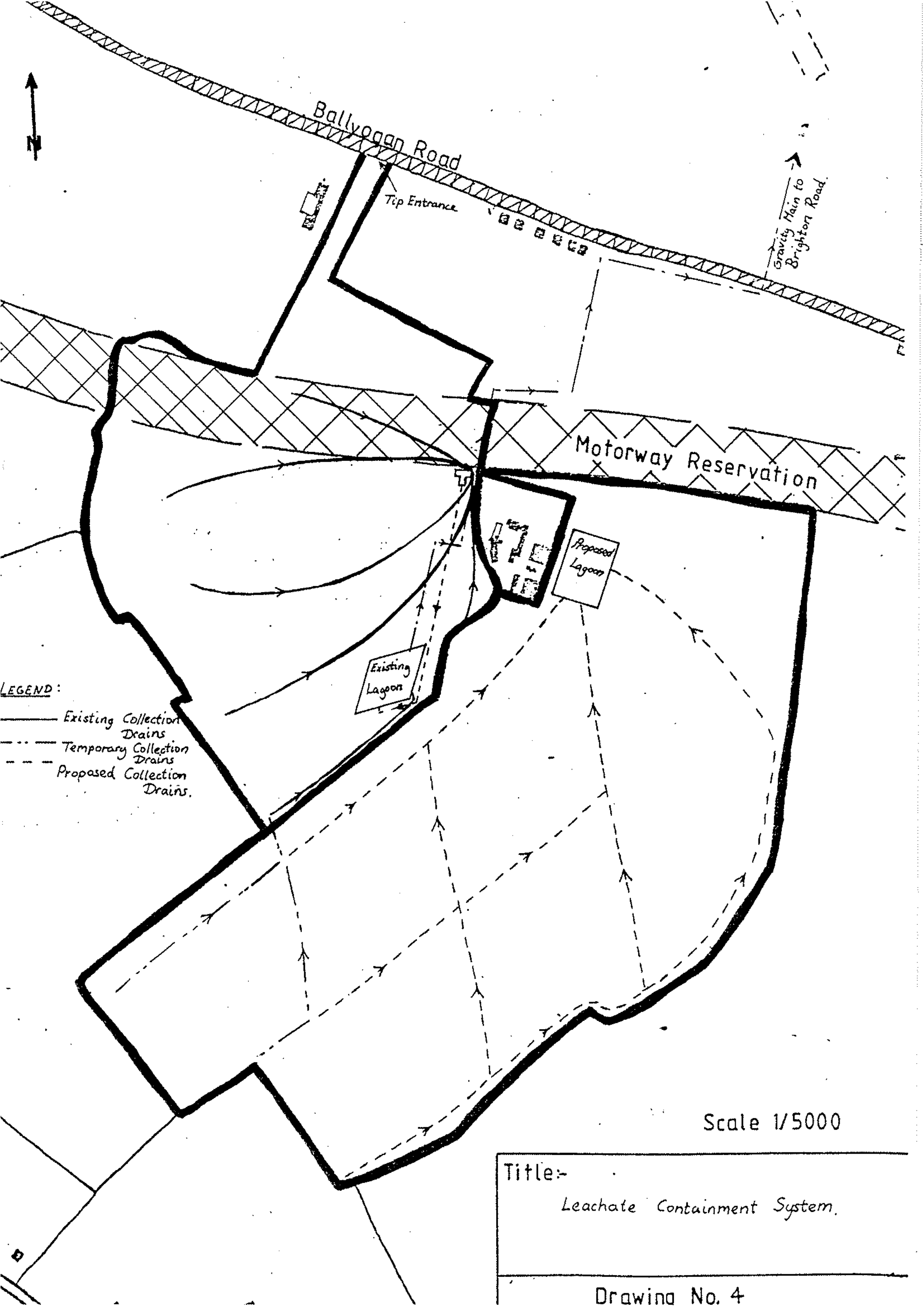
Drawing No. 2A.

SECTION A.A.



Drawing No. 2B.

SECTION B.C.D.


N
Ballyogan Road
Tip Entrance
Gravity Main to Brighton Road.
Motorway Reservation
Proposed Lagoon
Existing Lagoon
LEGEND:
Existing Collection Drains
Temporary Collection Drains
Proposed Collection Drains.
Scale 1/5000
Title:-
Leachate Containment System.
Drawing No. 4

THE DEVELOPMENT OF A MODERN LANDFILL SITE

AT WHITERIVER, CO. LOUTH

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April 22/23, 1986.

LOUTH COUNTY COUNCIL

THE DEVELOPMENT OF A LANDFILL SITE AT WHITERIVER FOR LOUTH COUNTY COUNCIL

INTRODUCTION

This paper describes the various aspects of developing a modern landfill site at Whiteriver, Co. Louth, from site identification and investigations, public consultations and court hearings, design, construction, total costs through to its operation and management.

APPOINTMENT OF CONSULTANTS

Because of the increasing objections and complaints from people concerning the existing dumps, and the possibility of the location of a new dump close to, and sometimes not so close to their dwellinghouse or lands, the County Council took the decision that any new dump to be provided for the mid-Louth area, would be upgraded to a more controlled operation to minimise environmental damage. This controlled operation is known as sanitary landfill.

The basic definition of sanitary landfill is that it is a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilising the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume and to cover it with a layer of earth at the conclusion of each days operation, or at such more frequent intervals as may be necessary.

In 1979, the Council engaged Messrs. Aspinwall & Company, Consulting Engineers, specialising in Water and Waste Management, to advise on the selection, design and operation of a new landfill site.

The paper which follows is based on the work carried out by Messrs. Aspinwall & Company for the Council, and contained in his report to the Council on the selection and design and operating proposals for the Whiteriver Site.

LANDFILL LOCATION SELECTION CRITERIA

At about this time the North Eastern Regional Development Organisation promoted a Groundwater Study of the Region which includes Co. Louth. The investigation was carried out by An Foras Forbartha with the assistance of the Geological Survey Office.

Subsequententy, the Geological Survey Office issued its own proposals for an aquifer protection policy for use by Local Authorities in the preparation of Waste Management Plans.

These two reports provided for the systematic survey of areas which might be considered suitable for a landfill site.

The Aquifer protection policy is designed to protect both individual borehole sources and the aquifer in general. In Ireland most geological formations will yield sufficient water for a domestic supply ($1m^3$/day) and are therefore classed as aquifers. In practice however, the policy is aimed at the protection of aquifers yielding more than $50m^3$/day. The policy operates by dividing the County into zones, as follows:-

Zone 1	Areas within 1km of a Groundwater source.
Zone 2	Areas underlain by major resource aquifers, excluding those areas where they are overlain by thick drift cover or other impermeable confining strata.
Zone 3	Areas underlain by minor aquifers, except where they are overlain by thick drift deposits or other impermeable confining strata.
Zone 4	All remaining areas where Groundwater is of no regional importance although small domestic supplies of Groundwater may be obtained.

In each of these zones specific development may be prohibited or subject to special control. Waste disposal sites are thus prohibited from zones 1 and 2. They may be allowed in Zone 3, depending on the degree of protection sought and the balancing of interests between the need to protect groundwater sources and the need to find waste disposal sites. No restrictions are applied in Zone 4, and it is to those areas that the search for a waste disposal site is best directed.

In order that we may ascertain which areas of the County would be classed or grouped into a particular zone, it is necessary to examine the geological succession of rocks present and their potential for groundwater development. The succession of rocks present in County Louth from the oldest to the youngest are the Ordovician, Silurian, Carboniferous, Tertiary, and Quaternary.

The silurian rocks underlies virtually all the central lowland area of the County between Dundalk and Drogheda. The Ordovician outcrop as small pockets of inliers within the Silurian. Well yields in these formations are generally small and sometimes nil. Such groundwater supplies as can be found are usually drawn from fissures and fractures in the weathered upper 30 metres of the bedrock. These rocks are classified as non-aquifers.

The lower Carboniferous limestones under lie an areas of $22km^2$ in the Boyne Valley near Drogheda; an area of $33km^2$ near Ardee and an area of $60km^2$ over several zones north of Dundalk and in the eastern part of the Cooley Peninsula. Well yields in the limestones vary; yields of up to 12l/s have been obtained but they may also be dry. They are however generally classified as an aquifer with development potential.

Tertiary igneous rocks outcrop in the Cooley Peninsula. These are classified as non-aquifers.

In the Quaternary Group we have three main divisions,

(a) Glacial Sands and Gravels
(b) Raised Marine Deposits
(c) Boulder Clay

(a) Glacial sands and gravels cover an area of 120 km² throughout the Cooley Peninsula, central Louth and at Drogheda. The sands are often associated with lenses of boulder clay. The deposits vary in thickness from 71m in Cooley, 37m in Central Louth to 30 m in Drogheda. At Drogheda, Ardee and Cooley the glacial sands and gravels are in hydraulic continuity with the underlying lower limestones and form a single important aquifer. Elsewhere they lie on the Silurian. Well yields are variable throughout the deposits. However the glacial sands and gravels are considered an important aquifer.

(b) Raised marine deposits occur at Dundalk, Dromiskin, Dunany and Baltray, totalling 40 km² in area. Fine grained silts predominate with interbedded sands and gravels. The deposits are up to 25 metres thick at Dundalk, and they serve as local aquifers. They are underlain by the Silurian.

(c) Boulder clays also lie on the Silurian and do not yield water to wells except where local lenses of sand and gravel occur. They are not considered to be significant aquifers.

The following tentative zoning is suggested with Zone 4 as the most likely resource for waste disposal.

Zone	Formation Outcrop
1	Area within 1 km of a public supply borehole
2	Lower limestones Gracial sands and gravels
3	Raised marine deposits
4	Ordovician and Silurian Tertiary igneous Boulder Clay

From the definition it can be seen that modern sanitary landfill practice requires substantial amounts of unconsolidated earth materials to cover the refuse at the end of each day of disposal. Materials will also be required for final restoration of the site, and may also be necessary to construct earth bunds for the purpose of retaining refuse. The availability of such materials is an important factor to successful landfill management.

Where bedrock, whatever its type, occurs at or close to the surface, it is unlikely that sufficient suitable materials will be naturally available for the landfill development. Consequently, this constraint is one of the selection criteria even though the rock may be classified as Zone 4.

The major constraints on landfill in County Louth is got by superimposing the viable bedrock aquifers, the viable superficial aquifers the areas where bedrock outcrops at or close to the land surface.

FINDING A SITE

Over a period of some three years various lands were offered to the Council as landfill sites. However, on examination all proved unsuitable for various reasons, e.g. marshy ground, danger to local aquifer, insufficient or no cover material available, too small. In all some twenty sites were investigated or examined during this period.

In 1980, a site of 27 acres, situated at Whiteriver, came on the market. The site was located within the residual area suitable, on a County scale at least, for landfill. The site was examined superficially and was considered to show good possibilities for development as a landfill site, subject of course to a detailed site investigation. This was not considered feasable before acquiring the property because of the sensative nature of the proposed development. After the first examination, the site was considered to have the following merits,

- (i) No surface water problems
- (ii) No visable shallow groundwater problems
- (iii) Centrally located for waste collection
- (iv) Clay available on site for cover material (perimeter ditches up to 2 metres in boulder clay)
- (v) Located in a sparsly populated area (only two inhabited dwellinghouses within 500m of the site)
- (vi) Large size so that the expenditure necessary to develop and operate a modern landfill correctly would be justified.

The site was purchased in August 1980.

The site is located on an elavated and undulating plateau to the south of the River Dee. The maximum height of the plateau is about 250m A.O.D. at a location of 4 km southwest of the site. The site is located at an elevation of about 120m A.O.D.

The principle river is the River Dee which flows in an easterly direction through Ardee about 5 km north of the site. The main tributaries of the Dee are the Kieran in the west, and the Whiteriver which flows east passing 400m south of the site. A major tributary of the Whiteriver flows in a west to east direction 300m north of the site.

The site itself is crossed by an easterly flowing stream which has its source some 600m west of the site. The stream joins the Whiteriver 1.8 km downstream of the site.

In the southern half of the site land rises steeply from the stream to a height of about 127 A.O.D. The land in the norther half rises more gradually to a height of 117 A.O.D. along the western boundary.

SITE INVESTIGATION

A detailed site investigation was carried out in the summer of 1981. A series of 18 trial pits were excavated within the site area to identify the nature of the sub-strata to a depth of 3 - 5 metres and to examine their variability across the site.

The trail pits indicate that the superficial deposits are comprised chiefly of boulder clay which grades in places to thin clayey sand and gravel horizons. A typical trial pit profile consisted of topsoil up to 0.5m thick, weathered mottled clay to a depth of between 1 and 2 m grading down into stiff grey brown boulder clay.

In the weathered zone of the boulder clay, slight seepage of water was observed in a number of the trial pits. The only occurrences of significance in the top 2 - 3 m across the site were in trial pits 4 and 11 where wet gravels are present.

In order to investigate the strata to a greater depth and to locate occurrences of groundwater and to provide undisturbed soil samples for laboratory analysis, four boreholes were drilled using the shell and auger method.

All the four boreholes were completed within the glacial deposits, the depths ranging from 15 to 17 metres. Drilling was not continued to bedrock, as it was considered that a sufficient depth of glacial deposits, essentially boulder clay, had been proven.

Bands of ill-sorted gravels were encountered at 14m depth in Borehole No. 1, 8m in Borehole No. 2, and at 6m and 10m in Borehole No. 4. Boreholes 2 and 3 were completed in gravel beds, the full thickness of which is not therefore known.

In the weather zone of the boulder clay slight seepage of water was observed in Borehole No. 1. A piezometer was installed to monitor this seepage, and showed a water level of about 0.7m below ground level. Groundwater was also encountered in the sand/gravel horizons mentioned above in all four boreholes. The water levels were recorded by piezometers installed at the relevant levels. In the case of Boreholes 1, 2 and 3 two piezometers in each hole were installed. The piezometers used consisted of a ceramic element connected by a 50mm ID plastic access tube to ground level.

In every case the water rose to a rest level well above the entry point, thus indicating the confined nature of the permeable horizons beneath the boulder clay. There is an existing well on site, adjacent to the farmhouse which is about 5m deep. The water level in this well is less than 1m below ground level.

The water levels in the deeper piezometer in each borehole and the approximate level of the well water and an adjacent spring were plotted. The levels are consistent with a groundwater gradient across the site in the gravel horizons from southwest to northeast with a recharge area somewhere to the south and west of the site. Thus, although the gravel horizons which were fully penetrated are thin and with no apparent stratigraphic inter-connection, there is evidence that hydraulically they are inter-connected and may, when considered with the gravel horizons in boreholes 2 and 3 which were not fully penetrated, constitute a local aquifer.

The permeability of the boulder clay was determined by laboratory testing of four undisturbed samples. The values fall in the range 10^{-4} - 10^{-5}m/day which corresponds to a low permeability.

The permeability of the sand/Gravel beds was determined by means of in-situ falling head tests on each completed borehole. The results indicate values in the range 0.1 - 10m/day (Cooper et al '67; Hvorslev 1951).

The testing established a considerable difference in the permeability of the boulder clay and the sand/gravel beds. Thus any water present within the strata will flow perferentially through the more permeable gravel beds and significant recharge of the gravels will not occur through the overlying boulder clay.

Other tests were carried out on the boulder clay to assess its suitability for use as a landfill construction material. These included liquid and plastic limits, Natural and optimum Moisture Content and Maximum Dry Density. The tests indicated that the natural moisture content equated with the optimum and that the boulder clay could be adequately worked for site construction needs.

The rainfall records for three stations in operation nearest the site at Ardee, Collon and Dunleer were examined for periods varying between 19 and 28 years. From the relative location of the site with respect to the three stations and bearing in mind its elevation, it is estimated that the mean annual rainfall at the site would be about 950mm.

Potential evaporation is measured at the climate station at Ardee. Based on a study of the figures over a 10 year period, the actual evaporation is taken to be 97% of the potential evaporation at 514mm.

The mean annual residual rainfall at the site is therefore taken as 436mm.

A V - notch weir was installed on the stream which crosses the site to measure the flow as it leaves the site. The catchment to the weir is approximately 0.24km² and included most of the site except for strips of land along the southern and eastern boundaries.

Predictions were made with regard to the flood flows resulting from this catchment above the weir based on rainfall, catchment, dimensions, soil characteristics and flow gradients from which a flow of 0.36 cumecs was derived for a 1 in 50 year return period based on the method given in the Flood Studies R port published in 1976.

As part of the site investigation, nine samples of water, four surface waters - two from the Whiteriver and two from the site stream - and give groundwater from the boreholes, were taken for analysis with the aim of establishing background quality. The following observations were made on the results.

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As part of the site investigation, nine samples of water, four surface waters - two from the Whiteriver and two from the site stream - and give groundwater from the boreholes, were taken for analysis with the aim of establishing background quality. The following observations were made on the results.

1. The quality of the Whiteriver upstream of Dunleer is confirmed to being of potable standard.

2. The site stream has slightly enhanced levels of amonia, possible due to agricultural drainage. It exhibits higher hardness and alkinity than the Whiteriver, having similar values to those found in the four boreholes. This suggests that groundwater is contributing to the stream flow in the local catchment.

3. The borehole samples all contained high levels of C.O.D. (and associated B.O.D.). Experience suggests that this is not representative of the bulk groundwater beneath the site, but is a result of the borehole construction method.

PUBLIC CONSULTATION AND COURT JUDGEMENTS

No sooner did it become known that the Council had purchased the land at Whiteriver for the purpose of setting up a waste disposal site, than opposition to the proposals developed. Initially this was from individuals, but soon became organised and co-ordinated by the Anti-Dump Committee formed to oppose and, if possible, prevent the development.

The objectors to the development were basing their case on the performance of the County Council in the operation of their existing dumps. The assurances given by Council Officials at the numerous meetings that took place with the local Anti-Dump Committee did nothing to allay those fears.

Following prolonged negotiations with the Anti-Dump Committee, they eventually agreed to allow the site investigations to proceed, provided that the results of the investigation and a copy of the subsequent report was given to them. However, it was with great difficulty that access to the site was gained to carry out the site investigation when pickets were placed on the entrances. Once on site the investigation and survey work proceed satisfactorily.

The Consultants Preliminary Report was presented to the Council and the Anti-Dump Committee in February 1982 at separate meetings. This did not however appear to allay the fears of the local people who continued to object to the siting of the landfill at Whiteriver and brought pressure to bear on individual Council members to oppose the project. An open invitation given at the local presentation to the Anti-Dump Committee to form a Monitoring Committee with the Council to oversee the proposed operation at Whiteriver was not accepted.

In March, 1983, three members of the Anti-Dump Committee, who owned land adjacent to the proposed site sought an injunction in the Circuit Court to restrain the Louth County Council from proceeding with the development of the site. The action was successful. However, the Council appealed this decision to the High Court.

In December, the High Court Judge ruled in favour of the Council, but strongly endorsed the suggestion of the Council that a Monitoring Committee be set up comprised of representatives of the Council and of the Local Committee to monitor the development and operation of the landfill site.

The Committee was set up in February 1984 and has met at monthly intervals since then. The Committee consists of seven elected members of the Council, six members of the Anti-Dump Committee, and one local landowner (not a member of the Anti-Dump Committee). The Committee is serviced by the County Secretary or his representative and the County Engineer or his representative also attend the meetings. While it was suggested at the first meeting of the Committee that it would be free to discuss and make recommendations on any matter which they felt would be of benefit to the local community, so far it has confined itself to overseeing the development and operation of the site. During development they were very particular about what items of work should be completed before the site opened for the intake of refuse.

DESIGN

In an average year rainfall will exceed evaporation at the site resulting in approximately 436mm of residual rainfall. Any of this residual rainfall infiltrating through domestic refuse in the waste disposal site will become contaminated due to the promotion of degradation processes and the solution of the soluble matter.

It was imperative that the sand and gravel aquifer identified at depth beneath the site should be adequately protected. The low permeability of the boulder clay which underlies the site should prevent the significant migration of leachate into the underground strata and provide a high degree of protection to any water in the gravel horizons at depth.

It therefore followed that a system of leachate containment collection and treatment prior to disposal must be provided to deal with leachate which would inevitably accumulate within the site.

The measures incorporated in the design of the Whiteriver Site to minimise leachate production include the following:-

1. The division of the proposed landfill area into four sections to be developed in succession.

2. The further division of each section or phase into a number of cells which will be filled separately and consecutively.

3. Each cell to be filled to the highest level, and if possible, to the design level before filling of the next adjacent cell commence.

4. Where possible, each phase to be completed to final design levels and fully restored before filling of the next phase commences.

5. Surface water and shallow groundwater to be prevented from entering the active landfill area by the provision of bunds and cut-off ditches.

6. The stream crossing the centre of the site to be diverted around the northern and eastern site boundaries outside the landfill area.

Even with these measures the volume of leachate will increase with time depending on the actual rate of waste input, and the actual infiltration. The average peak production is calculated to be up to $50m^3$/day during the active life of the site. On completion, and final restoration of the site, the longterm leachate production is calculated to be about $25m^3$/day with leachate strengths declining with time.

The design of the site has been based on an annual input of refuse of 20,000 tonnes or 80 tonnes per day. The life of the site is expected to be about 20 years assumming an emplaced waste density of 0.86 m^3. It is planned that the final configuration of the site will form an elongated spur of high ground extending northwards across the restored landfill. The southern border of the landfill is delineated 60m inside the site boundary, and this area of ground will be used for the storage of topsoil and surplus excavation material for use in final site restoration (Fig. 2). Along the western, eastern and northern sides, the landfill is inset approximately 15m from the site boundary to provide sufficient space for security fencing, access roadway and drainage channels. The northwest corner, where the existing buildings are located was set aside for the site office and stores, leachate lagoon and main entrance. In order to provide sufficient materials for the daily and final cover and the construction of bunds to contain the landfill, it will be necessary to excavate the site to an average depth of 3m over the landfill area.

Drainage of leachate in each phase will occur by gravity to the lowest point where manholes will allow for the monitoring of the leachate levels. The leachate will then be pumped to a lagoon situated in the main reception area near the site office. The lagoon will have a capacity of around 800m^3 and be installed with two surface aerators to permit a high rate of aeration. The partially treated leachate will initially be tankered to Blackrock for final treatment and disposal, but it is intended that if the effluent quality is of a sufficiently high standard, then the possibility of discharging it by pipeline to a sewerage works more convenient to the site will be investigated.

Landfill gas, consisting principally of methane and carbon dioxide is a natural product of landfill sites. The design includes a venting system consisting of a stone filled column with perforated collecting pipe in each cell to ensure safe disposal of the gases into the athmosphere.

Development work started on the site in February, 1984 with a view to bringing Phase 1 of the site into operation by September of the same year. The main items of work undertaken are now described (Ref.1).

The site stream was diverted around the northern and eastern perimeter of the site. It was intended at first that this would be in open channel but during construction it was decided to culvert it along the northern boundary using 450mm diameter closed jointed pipes. In order to provide a cut-off for shallow ground water seepage along the piped section the landfill side of the trench was lined with a plastic sheet taken across the bottom of the trench and under the main drainage pipe. A 75mm diameter land drainage pipe was provided along side the main pipe to pick up any infiltration into the trench.

Clay bunds were constructed around the perimeter of the landfill area to retain the refuse and provide a screen to the tipping area. The bunds are 2m high and have side slopes of 1 in 3 on the outside and 1 in 1½ on the inside. The bunds are provided with a 3m wide by 1m deep key into the undisturbed boulder clay to cut off any shallow land drains. An intermediate bund, also 2m high was constructed between phases 1 and 2 and it too provided with a key similar to the perimeter bunds. The perimeter bund is inset up to 15m from the existing site boundaries to allow space for the provision of fencing, drainage and services.

Clay for the construction of the bunds came from the complete excavation of Cell 1 and the partial excavation of Cell 2. Some material became unusuable in the wet weather of March 1984 and this was stockpiled at the southern end of the site. Material excavated from the keys under the bunds was also stockpiled in this area. The entire area of Phase 1 within the bunds was stripped of topsoil and this was also stockpiled at the southern end of the site.

In the lowest corner of Cell 1 a leachate collection manhole was provided, consisting of perforated precast manhole rings surrounded by clean open stone. A submersible pump delivers the leachate from here to the leachate holding tank beside the main entrance via a 75mm drain rising main.

In normal operation the pump is set to run automatically, controlled by means of float switches in the collecting manhole and holding tank. The leachate holding tank is of reinforced concrete construction and has a capacity of $25m^3$. It is located underground beside the main entrance: allowing easy access for tankers to empty it.

Within the site a 6m wide primary access road is provided which will serve the active landfill areas throughout the life of the site. A cattle grid over half the road width is provided at the main entrance and a wheel washing facility is provided on the exit lane. A secondary access road 4m wide is provided from the primary road to the tipping face in Cell 1.

A security fence and gates have been erected around the perimeter of the site and enclosing Phases 1 and 2 of the proposed landfill area. The fence is located between the existing site boundaries and the newly constructed bunds. Six metre wide security gates are provided at the main entrance and at the southwest corner of the fenced area. The entrance gates are in two halves, and in normal operation only one leaf is open. This has the effect of slowing down traffic at the entrance and yet is sufficiently wide to allow normal traffic through.

A permanent site office and stores, together with canteen and toilet facilities for the site staff was provided by renovating one of the existing buildings on the site. The building is so located that the foreman is provided with a good view of the entrance from the office.

Tree planting has been carried out on the outside slopes of the perimeter bunds. Varieties planted are mainly Scots fir, Adler, Japanese Larch and Norway Spruce. An occasional Mountain Ash, Poplar and Silver Birch are mixed in to give variety.

Off site, the recommended approach road to the site from Whiteriver Cross on the Dunleer/Collon Road, R169, was widened to give a carriageway width of 6m. The pavement was strengthened using a 200mm thick overlay of wetmix macadam, double surface dressed to cater for the additional heavy traffic resulting from the development. Some realignment of the roads around the north western corner of the site adjacent to the main entrance was also undertaken to improve junction layout and visibility.

The collection of surface water within Phase 1 proved to be a problem as it became discoloured due to the scouring action over the exposed boulder clay. This was overcome by excavating Cell 2 completely, except for a small sub-dividing clay bund. An intercepting ditch was excavated in Cell 3 along side Cell 2. In this way the surface water flowing across the site is intercepted in this trench and piped into Cell 2A. Surface water from the secondary road is similarly intercepted and also piped into Cell 2A. A high level overflow is provided between Cells 2A and 2B. A submersible pump in Cell 2B discharges the water into one of the manholes on the diverted main drain. The pump is controlled by a float switch which is adjusted to switch on only when Cell 2B is full and off with about 300mm remaining. In this way settlement of silts is allowed to take place in both parts of Cell 2, and satisfactory results have been obtained for suspended solids in effluents discharged therefrom.

The leachate lagoon was not included in the works carried out during 1984 as it was not considered essential to the satisfactory operation of the landfill in the first year. An additional measure of sub-dividing Cell 1 into two areas to further reduce leachate production was carried out before the site opened for the reception of refuse. However due to public pressure from the Monitoring Committee work started on the leachate lagoon in September '85 and was completed in December, 1985.

SITE OPERATION

The site has now been operational for approximately fifteen months. The normal hours of opening are 8.30 a.m. to 4.30 p.m., Monday - Friday. A facility is provided in the security fence beside the main entrance where individuals may deposit refuse when the site is closed in the evenings and at weekends. It consists of a securely enclosed area in which two collection skips/bins are placed. The refuse is deposited through two access ports in the wall into the bins. Access to the bins for emptying is from within the site.

So far, the Council has been generally satisfied with the operational aspects of the site. Initially there were some "teething problems" associated with the handling of the covering material ; boulder clay, in wet conditions. The problem was further aggravated by the low volume of refuse intake. This on average, during the first year, was only 15% (60 tonnes/week) of the design capacity, which resulted in a high clay: refuse ratio in the filled area. In an effort to increase the input of waste to the site, the Council, at the latter end of '85, re-examined its waste collectionstrategy. This resulted in the re-organisation of some waste collection routes so that refuse, which had hitherto been tipped at Sanitary Authority sites in Dundalk and Drogheda were now re-directed to Whiteriver. This additional influx of work had the immediate effect of increasing the total weekly input to 180 tonnes or 45% of design capacity.

There are two full time County Council operatives employed on site. One is stationed at the site entrance office and his responsibilities are to visually inspect the type of waste entering the landfill site, to estimate the quantity/weight of the waste, to implement "charges" system and collect monies from persons tipping in the site and to keep a detailed log of all operational aspects of the landfill site. The second operative main functions include directing vehicles to the tipping area, collecting paper fromthe litter screens, assisting the Machine operator in the daily covering of the waste, and generally to carry out day to day inspections and basic maintenance of the various mechanical units i.e. pumps, aerators, etc.

At present, only domestic, commercial and industrial type wastes are accepted on the landfill ; toxic/hazardous wastes together with septic tank sludge are excluded. Todate, 80-90% of the waste has been domestic in origin; the low percentage of commercial and industrial waste may be directly attributated to the higher costs levied at Whiteriver as opposed to those at Dundalk and Drogheda Disposal Sites. A comparison of costs is given in Table:- 1

Table 1

TYPE OF VEHICLE	WHITERIVER	DROGHEDA	DUNDALK
Large trailer	£15	-	-
Skip/bin	£10	£5	£5
Car & small trailer	£2	-	-

The leachate lagoon was completed in December 1985, taking four months for total construction. It has a liquid capacity of 800m³ and operates as a combined aeration and settlement chamber. It was constructed using earth bunds, and utilised a High Density Polyethylene (H.D.P.E.) membrane liner for waterproofing. A concrete base was provided to act as a resting pad for the Aerators when the leachate is not present, while at the same time holding the membrane in the base of the lagoon firmly in place. Based on a theoritical average peak leachate production of 50 m^3/d the lagoon provides sixteen days retention for degradation of the influent. The oxygen required for this derobic digestion of the waste water is approximately 500 - 600 Kg/day (based on an average $B.O.D._5$ strength of 6000 mg/l) and is provided by two floating aerators, each powered by a 7.5 kw electric motor and operating in tandem or independently as required. The treated leachate, after settlement, is drained off, (manually at present) to the holding tank (formely used to contain raw leachate) from where it is transported by tanker to Blackrock for final treatment and disposal. The Council has been assured by its Consultants that the B.O.D. and the ammonia levels in the raw leachate will be considerably reduced by this form of treatment. Indeed a similar plant operating at Bryn Posteg in Wales is producing an excellent effluent, $B.O.D._5$'s in the order of 40 - 60 mg/l are consistently achieved. Regretably due to some protracted and as yet unresolved problems with the operation of the Aerators, the Council has not been able to commission the Effluent Treatment Lagoon.

The overall leachate handling and treatment system is designed to operate completely automatically by means of timers, level control probes and therefore should require minimal attention from plant operatives. Fig. illustrates the flow sequence and unit operations involved in a complete treatment cycle.

The Council experimented with two machines for the compaction and covering of the refuse. Initially a tracked loading shovel was used and then a landfill compactor. Neither were satisfactory. The narrow tracks on the loading shovel allowed it to bog down in the refuse too readily, while the landfill compaction was too large and cumbersome. A tracked excavator is now in use and seems to be working satisfactorily. In the Whiteriver context it has proven a most versatile machine readily coping with the routine daily operations, namely:-

1. Loading of cover material onto the lorry for transportation to tipping area.
2. Levelling of refuse.
3. Emplacement and levelling of cover material.
4. Dressing up and tidying the open face of the landfill.
5. Minor excavation work e.g. excavation surface water collection channel.

MONITORING AT THE SITE

In drawing up an Environmental Monitoring Programme, there are several important aspects to be considered, namely:-

1. Sources to be monitored -
   i) Ground Water
   ii) Surface Water
   iii) Leachate
   iv) Landfill Gas

2. The number, location and placement of sampling stations.

3. Frequency of sampling/monitoring.

4. Parameters to be monitored.

5. Methods of Sampling.

In order to monitor surface waters, ground water and refuse water quality the following sampling programme was adopted.

1. Routine sampling of the perimeter ditch water on the upstream and downstream side of the site.

2. Routine sampling of local wells on nearby properties within 500m of the landfill.

3. Installation and routine sampling of two boreholes down the hydraulic gradient from the site.

4. Routine sampling of leachate manhole and the treatment lagoon to determine quality of both raw and treated leachate.

5. Routine sampling of on-site boreholes until they have to be capped during the preparation of new tipping areas.

6. Occasional sampling of local wells located and within 1 Km of site but excluding those within 500m.

The above is summarised in Table 2 below

Table 2

MONITORING DOMAIN	NO. OF SAMPLING POINTS	MONITORING FREQUENCY	
		Chemical Analysis	Water Level
Ground Water - occasional	30	Annually	-
routine	7	Monthly	Monthly
Surface Water	3	Monthly	Monthly
Refuse Water	1	Monthly	Monthly

The location of all routine sampling points are shown in Fig. 3

GROUND WATER

Of the seven boreholes currently being monitored four are within the site boundary and three off site (within 100m of the landfill). Two of the three off site boreholes were purposely drilled to the east of the site in order to tap into the hydraulic gradient.

The profile of these boreholes were similar to the original four. Water bearing gravel and sand at 9m in borehole No. 5 and at 6m in borehole No. 6. Both holes were finished off at 10m in the gravel beds.

Of the original four boreholes drilled on the site at the investigation stage, three have been retained as sampling points, while the third (Borehole No.1) was sealed during the construction of the main perimeter bund as it came within the key of the bund.

In addition, a well which had previously existed on the site was also retained as a sampling point. This source serves the main site office, wheel wash structure and the skip/bin storage area. The well is located within 15m of the leachate lagoon and any unforseen leakage therefrom to the surrounding ground water would quickly manifest itself in this monitoring point.

SURFACE WATER

Surface water is sampled both upstream and downstream of the site. The upstream point is near the north west corner of the site. The downstream location is to the east of the site, at a point approximately 150m downstream of the landfill (Fig.3).

The water in Cell 2 is also sampled. This cell, as described previously acts as a temporary silt lagoon and is used to collect and settle the discoloured surface water from within phase 1. It is essential that the water in the cell be of a high quality before being discharged to the re-routed main stream, which eventually enters the Whiteriver (a source of potable water supply).

REFUSE WATER/LEACHATE

Leachate arising within the landfill gravitates through a series of stoned drains to a central collection sump, whence it is pumped to a leachate hold tank of reinforced concrete construction and of approximately 25m^3 capacity. It is located underground beside the main entrance. Samples are collected from this tank. When the leachate lagoon becomes fully operational, this tank will be used to collect treated effluent, with raw leachate being pumped directly to the lagoon.

ANALYSES

The range of parameters monitored varies. Two suites of analyes are currently in use; these are referred to as full and partial analyses. The parameters included in each group are given in Table 3

TABLE 3

FULL ANALYSIS	PARTIAL ANALYSIS
B.O.D.	Yes
Cond	Yes
PH	Yes
Phosphate	Yes
C.O.D.	Yes
Ammonia	Yes
Chloride	Yes
Suspended Solids	Yes
Copper	No
Zinc	No
Iron	No
Manganese	No
Cadmium	No
Nickel	No
Chromium	No
Potassium	No
Sodium	No
Calcium	No
Magnesium	No

A full analysis is carried out quarterly on all samples
A partial analysis is carried out monthly on all samples.

Analysis of leachate samples collected during period January '85 - November '85 are summarised in Table 4. Several brief comments can be made:-

Even within a relatively small area of landfill (0.3 hectare) significant variations can occur in leachate strength. It is not clear whether these are due to our method of sampling (grab as opposed to composite sampling), to other factors such as dilution effect, type of waste etc. or perhaps to a combination of these factors. It is proposed to increase the frequency of sampling at the treatment lagoon as soon as the Surface Aerators have been commissioned. By doing this, it is hoped to obtain a more accurate picture of the leachate composition and in particular to assess the level of plant preformance in relation to reducing the B.O.D. and Ammonia concentrations in the raw substrate.

Toxic metals (Ni, Cr, Cu, Cd) concentrations were not markedly higher than those found in domestic sewage.

The concentations of phosphorous are relatively low. An optium ratio of B.O.D. : N : P of 100 : 5 : 1 is recommended for sewage treatment plants. At Whiteriver it is proposed to add phosphous in the form of Phosphoric acid to achieve a properly balanced substrate.

Ammonia is present in high concentration ranging from 11 - 475 mg/l. This is in line with analyses of leachates from other relatively young landfill sites.

REPORT OF ANALYSIS FOR 1985

TABLE 4

SAMPLING POINT - LEACHATE TANK

	Jan '85	Feb '85	Mar '85	Apr '85	May '85	Jun'85	July'85	Aug '85	Sept'85	Oct.'85	Nov.'85	Dec.'85
B.O.D.	960	6000	720	179	7560	6550	17,250	2440	2250	5640	1300	
Ph	7.1	6.7	6.5	7.0	6.6	6.5	6.4	6.8	6.9	6.7	7.1	
Phosphate	0.26	0.55	0.9	0.7	5.8	2.9	20.1	0.5	0.21	2.71	0.48	
C.O.D.	1308	9690	4050	3307	8540	-	19095	2960	2770	-	1934	
Ammonia	14.0	30.0	42.2	11.3	93.2	124	475	69.0	49.8	127	47.8	
Chloride	15	667	566	-	-	532	658	247	12	266	134	
Suspended Solids	54	74	135	82	380	181	492	224	2	207	295	
Sodium	75.36	-	-	37.2	-	-	-	137.0	-	-	90.7	
Potassium	29.30	-	-	540	-	-	-	4.47	-	-	135.5	
Zinc	0.180	-	-	0.101	-	-	-	0.550	-	-	0.410	
Mangenese	14.00	-	-	0.058	-	-	-	6.55	-	-	4.40	
Iron	-	-	-	13.2	-	-	-	40.4	-	-	20.0	
Cadmium	-	-	-	-	-	-	-	0.0004	-	-	0.0013	
Nickel	-	-	-	-	-	-	-	0.032	-	-	0.010	
Chromium	-	-	-	-	-	-	-	0.016	-	-	0.008	
Calcium	-	-	-	-	-	-	-	369.0	-	-	309.0	
Magnesium	-	-	-	-	-	-	-	320.0	-	-	128.0	
Copper	-	-	-	-	-	-	-	0.008	-	-	0.006	

Results in mg/l except for PH

All analyses carried out on "Grab" samples

COSTS

Louth County Council have made a significant financial investment both in the form of expertise to investigate, design, operate and monitor the development and restoration of the landfill and to purchase and maintain appropriate capital items and equipment. The costs in Punts have been set out in Table in accordance with the system developed by Aspinwall & Co. for the Department of the Environment (Ref. 2) which permits a standardised assessment and comparison of the total cost of waste disposal by landfill. The total void available at the site for filling with waste has been estimated to by 500,000m^3 and therefore all site assessment, development, restoration and aftercare costs have been divided by the site capacity in order to calculate their respective unit costs.

Unfortunately, in this brief assessment of landfill costs it has not been possible to consider the relationship of expenditure and revenue over the life of the site using discounted cash flow techniques.

The cost of the phased development works over the life of the site consisting of earthworks, drainage and fencing, are estimated to be about £234,294. which is equivalent to £0.47/m^3.

The progressive restoration of the landfill site will ensure that leachate generation is minimised and that the operation of the landfill is environmentally acceptable. It is estimated that the cost of restoration and after care will be about £0.29 per m^3 and £0.18 per m^3 respectively.

Operational costs are by far the most significant costs incurred in the Whiteriver site. It is estimated that the operational costs amount to between £7.06 and £10.59 per m^3 depending on the present input rate (8,000 tonnes/annum). This includes the cost of tankering leachate to the Blackrock sewage works and it is hoped that this cost will eventually be eliminated by the construction of a piped discharge of treated leachate to a more convenient sewage works.

TABLE 5

Initial Site Assessment, Acquisition and Development Costs

	Actual Cost	Unit Cost	Total Unit Cost
	£	£/m³	£/m³
Site Assessment Costs			
Site and Soil Survey	8,470.00	0.018	0.018
Site Acquisition Costs			
Land Purchase (incl. legal costs)	76,235.00	0.153	0.153
Initial Site Development Costs			
Site Clearance, Drainage & Earthworks	156,238.00	0.312	
Highway Improvement and Site Road	97,882.00	0.194	
Security Fencing and Gates	23,529.00	0.47	
Electricity, Telephone & Water	9,411.00	0.018	
Site Office & Storerooms	24,470.00	0.048	
Leachate Lagoon incl. M & E Works	56,470.00	0.112	
Legal, Design & Supervision Costs	77,647.00	0.153	
SUB TOTAL	445,647.00	0.884	0.884
TOTAL UNIT COSTS	530,352.00		1.055

The costs incurred in developing and operating the Whiteriver Landfill Site are similar to the costs for a low input modern landfill site which has been designed and operated to the standards recommended by the Landfill Practices Review Group of the Department of the Environment (UK). The estimated total costs of site development and operation are shown in Table 6. It is interesting to note that operation costs represent the major area of expenditure at the Whtieriver Landfill, with site assessment representing only 0.2% of the total costs.

TABLE 6

Total Landfill Costs

	Actual Unit Costs £/m³	Actual Percentage of Total Cost	Typical Modern Landfill Costs (Ref 2)
Site Assessment	0.018	0.2%	1.0%
Site Acquisition	0.153	1.4%	6.9%
Initial Site Development	0.884	8.2%	8%
Phased Development	0.47	4.3%	4.4%
Restoration	0.294	2.7%	2.9%
Aftercare	0.176	1.7%	4.1%
Operational Costs (range £7.06 to £10.59 assume average £8.82/m³)	8.823	81.5%	72.7%
	£10.818/m³	100%	100%

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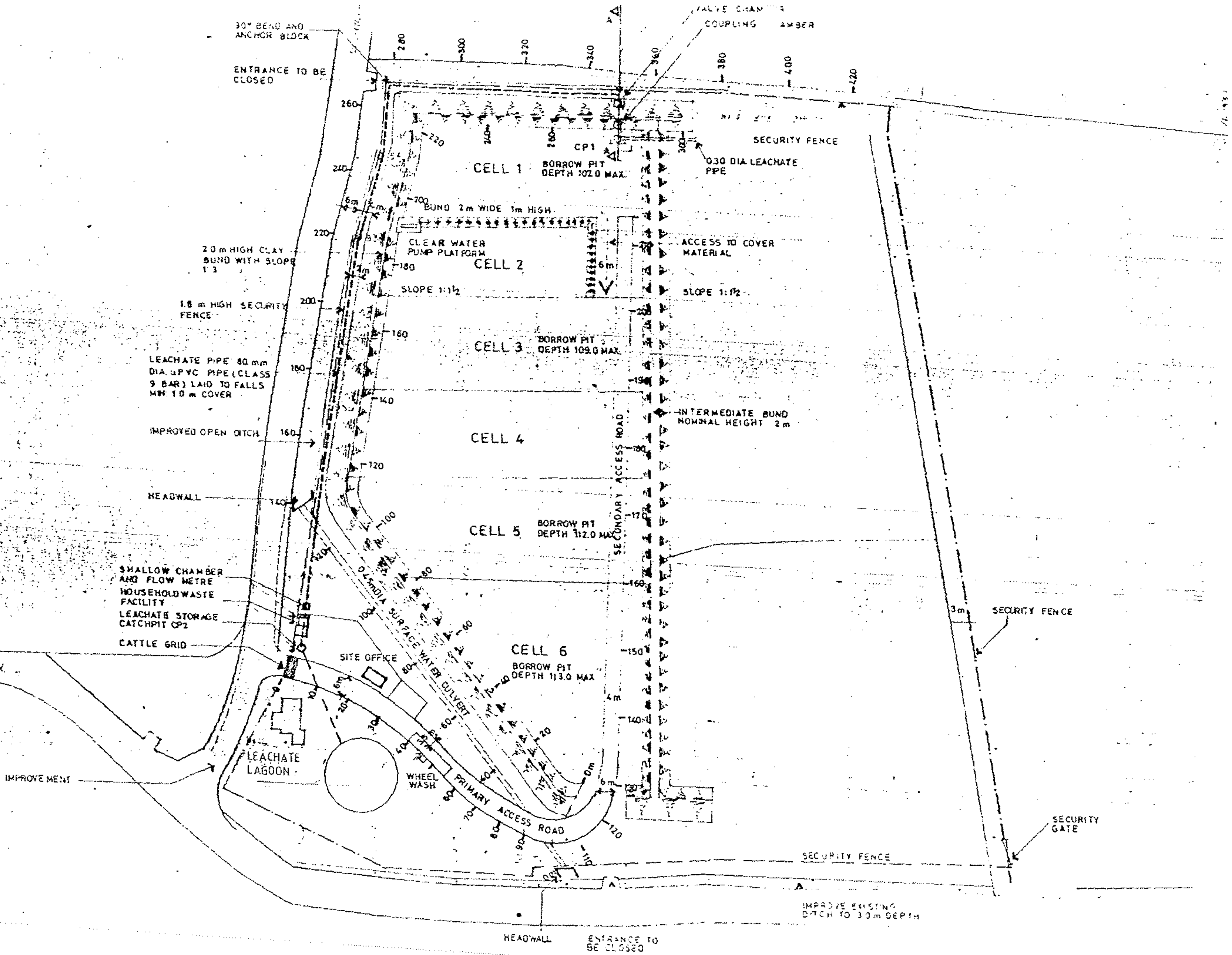


Fig. 1 General layout of Phase 1

FIGURE 2

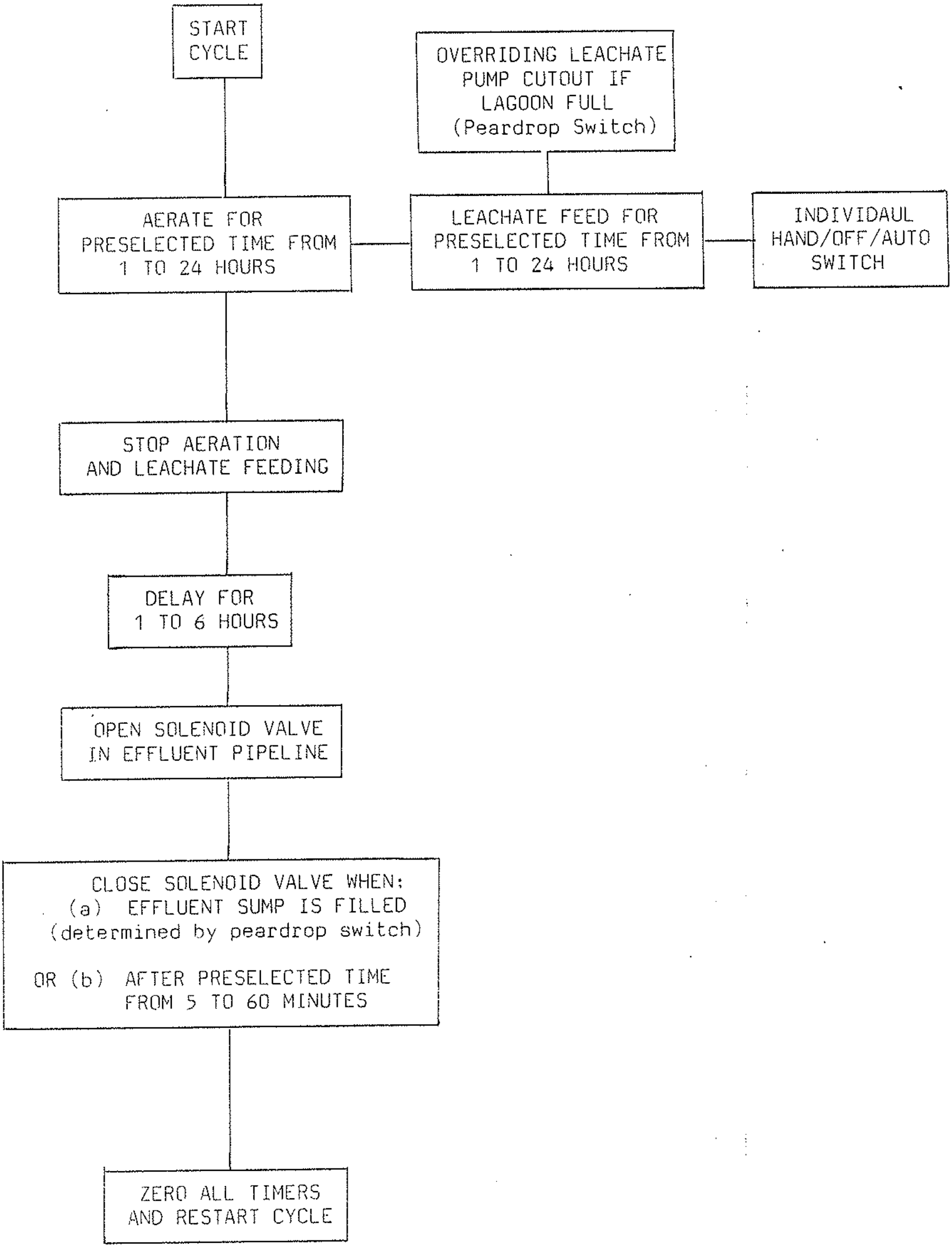
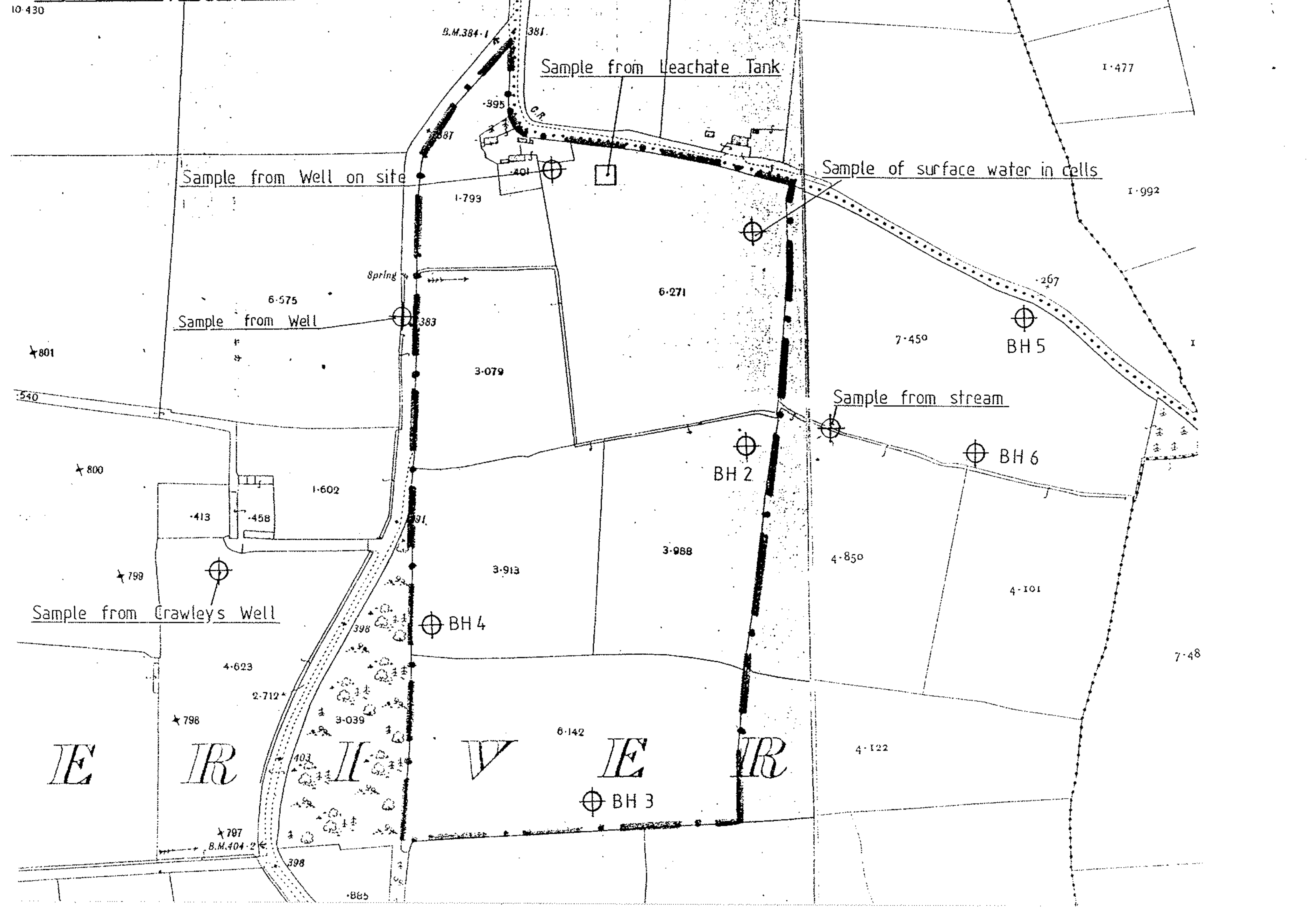

START CYCLE
OVERRIDING LEACHATE PUMP CUTOUT IF LAGOON FULL (Peardrop Switch)
AERATE FOR PRESELECTED TIME FROM 1 TO 24 HOURS
LEACHATE FEED FOR PRESELECTED TIME FROM 1 TO 24 HOURS
INDIVIDAUL HAND/OFF/AUTO SWITCH
STOP AERATION AND LEACHATE FEEDING
DELAY FOR 1 TO 6 HOURS
OPEN SOLENOID VALVE IN EFFLUENT PIPELINE
CLOSE SOLENOID VALVE WHEN:
(a) EFFLUENT SUMP IS FILLED (determined by peardrop switch)
OR (b) AFTER PRESELECTED TIME FROM 5 TO 60 MINUTES
ZERO ALL TIMERS AND RESTART CYCLE

Fig. 3 — Sampling points



THE DISPOSAL OF INDUSTRIAL WASTES

BY

E. McMahon, Ph.D., IIRS

Industrial wastes are a major proportion of the total amount of waste generated in Ireland. At 1.1 mt/a (excluding mining wastes) the quantity of industrial waste requiring disposal exceeds that arising from domestic sources. Industrial wastes constitute a wide range of wastes whose characteristics vary widely from one type to another.

Disposal Mechanism:

Industrial wastes are disposed of by a number of means as shown in Table 1 below:

TABLE 1: DISPOSAL ROUTE OF WASTES FROM MANUFACTURING INDUSTRY

METHOD	T/a	PROPORTION
Landfill	280,000	25%
Landspread	200,000	18%
Incinerated	15,000	1%
Recovered	550,000	48%
Other	90,000	8%
TOTAL:	1,135,000	

It can be seen that recovery plays a major role in reducing the volume of waste requiring disposal. It is also clear that the majority of non-recoverable wastes are disposed of to landfill.

Hazard Rating:

The great majority of industrial wastes are non-hazardous and pose few problems different from the disposal of domestic wastes. In legal terms waste can fall into either of two categories.

a) Non-hazardous waste which is controlled under the General Directive on Wastes (S.I. 390, 1979).

b) Hazardous Wastes which are controlled under the EEC Directive on Toxic and Dangerous Wastes (S.I. 33, 1982).

In practice there is a third category of industrial waste which is not regarded as toxic or dangerous but which does pose disposal problems quite different from those of domestic waste. Examples include offal, paunch contents, primary sludges and certain metal wastes.

The proportions of industrial wastes falling into each category are shown below. In these, as in all other figures relating to industrial wastes, quantities should be regarded as approximate only.

TABLE 2: CATEGORIES OF WASTE FROM MANUFACTURING INDUSTRIES:

	t/a
Total Waste	600,000
Special Waste	56,000
T & D Waste	20,000

Broadly speaking, all non-hazardous wastes are disposed of without problem, with the majority going to local authority tipheads. Sometimes, these tips are not as conveniently sited or do not have sufficiently flexible arrangements as waste disposal contractors would like. However, each county has at least one tiphead which will accept non-hazardous industrial and commercial waste.

The method of disposal of Hazardous Wastes and other types of special wastes is shown in Table 3 overleaf. The disposal of special wastes can often be accommodated on local authority or private tipheads by the use of specific disposal methods. Liquid wastes and sludges will require dewatering wherever possible. Offal and food wastes can be disposed of by deep-burial. Non-presciption drugs and chemicals can be encapsulated in cement before disposal. Certain metal sludges can be accommodated on tips by packaging in plastic barrels and burial on mature areas of established tipheads. In general however, local authorities do not like establishing non-standard disposal methods and in certain cases refuse to accept wastes which pose few technical problems. Examples here include oily wastes, certain chemicals and certain metal wastes.

TABLE 3: FATE OF SPECIAL WASTES:

		PROPORTION DISPOSED OF BY			
TYPE	QUANTITY tonnes/a	LANDFILL	INCINERATED	RECOVERY	OTHER
EEC defined toxic waste	20,000	11%	49%	22%	18%
Chemical, oil, other problematic wastes	17,000	63%	4%	4%	29%
Metal & chemical treatment plant sludges	39,000	88%	-	-	12%
Total Special Wastes	76,000	62%	14%	7%	17%

The disposal of wastes designated as Toxic and Dangerous does pose considerable problems for the producer. There are no private contractor's tipheads within the country licensed for T & D wastes. A small number of companies do have approval for disposal of such wastes on their own tipheads but the majority of companies producing such wastes which require disposal by landfill must look to the use of local authority tipheads or export.

In seeking approval for the use of a local authority landfill, companies will most usually be disappointed. All local authorities are extremely reluctant to accept T & D wastes onto their tipheads, for one or more of the following reasons:

(i) The L. A. tiphead is either poorly sited or poorly managed and, as such, the proposal is not acceptable for techanical reasons.

(ii) The reluctance of technical officers within the council to accept responsibility for approving the acceptance of such wastes.

(iii) The refusal by councillors of a local authority to permit the acceptance of such waste onto their tips, on political grounds.

In retrospect, the decision to delegate to each local authority the responsibility for disposal of toxic and dangerous wastes is now seen by some to be wrong. The technical complexity of the issue, and the relatively small amount of hazardous waste in relation to the number of local authorities suggests that this area would best be controlled by a single body at national level which would be free from the complications of local politics.

As the categorisation of a waste as Toxic and Dangerous or not so, is critical in determining its acceptability it is important for the waste producer to be certain on this matter. With certain categories of waste such as solvents there is little ambiguity. However, in the case of metal sludges, certain wastes may be categorised unnecessarily as toxic and dangerous. I attach a paper from an IIRS colleague which discusses this matter in some detail. The results of leaching trials are of particular interest to hydrogeologists in determining the acceptability of disposing of a particular waste on a specific tiphead.

In recent years, where landfill in Ireland was not available, hazardous wastes were despatched to the U.K. for land disposal there. There is now an increasing reluctance on the part of the U.K. authorities to accept these wastes and this route is now contracting in usefulness.

Existing arrangements for the disposal of industrial wastes by landfill are not satisfactory and there is no indication that matters will substantially improve over the next few years. Advances will be achieved if the public and politicians come to regard industrial waste disposal as a technical area into which they should have little input, especially on specific wastes. The application of improved technical evaluations of tip sites and wastes will lead to improved standards which, ultimately, will help to reduce the high profile that this area occupies in the public mind.

/kos

WHAT IS A TOXIC WASTE?

R. G. Boelens, I.I.R.S. Shannon Laboratory

> 'There are no harmless substances; there are only harmless ways of using substances'.
>
> Emil Mrak, Chancellor Emeritus, University of California at Davis.

While the properties and uses of poisons have been known since at least 1500 B.C. it was the late Middle Ages before the task of defining a poisonous substance was given serious consideration. Philippus Aureolus Theophrastus Bombastus von Hohenheim, better known as Paracelsus, was the first to promote the idea of the 'toxicon' or toxic substance as a chemical entity. He also initiated the views that experimentation is essential in examination of responses to chemicals; that one should make a distinction between therapeutic and toxic responses of chemicals; that these properties are sometimes but not always indistinguishable except by dose, and that one can ascertain a degree of specificity of chemicals and their therapeutic or toxic effects.

With this background it may seem rather ridiculous that 200 years later we are still grappling with the definition of a poison. Even the word itself presents difficulties. But whether we choose to call them poisons, toxicants, dangerous or hazard substances we should accept that virtually every known chemical and physical agent is capable of producing a deleterious response in an organism under certain conditions and that 'toxicity' as the relative measure of potency, is the characteristic of most concern.

Legislators and administrators responsible for controlling toxic substances have the choice of using either an inclusive or exclusive resister. But the suggestion that all chemicals will be regarded as hazardous until proven otherwise is not only controversial, it is quite simply impractical due to the cost and effort involved. Thus it is the inclusive register, such as that contained in E.E.C. Directive 78/319, which has generally been favoured. But this system too presents difficulties. The criteria adopted for including a substance in the list cannot be based on toxicity alone since if this were the case even domestic bleach would be tightly controlled. Hazard depends on risk and risk depends on the possibilities, type and extent of exposure. Thus the classification of chemicals for legislative purposes will take account of various factors, including:

- Quantity produced
- Use pattern (open or closed system)
- Safety record
- Solubility
- Persistence
- Bio-accumulation potential
- Mutagenicity, carcinogenicity, teratogenicity
- Toxicity (acute, chronic; oral, dermal inhalation; mammals, birds, fish, invertebrates).

Perhaps the greatest problem with the inclusive list is that it tends to give equal status to a variety of materials with vastly different characteristics and correspondingly different hazard potential. Is it fair, one might ask, to list a naturally-occurring substance which is an essential nutrient, such as copper, with organic-halogen compounds which are largely synthetic and frequently used as biocides? Such anomalies are, unfortunately, impossible to eliminate and we can accept them providing use of the register allows some flexibility in interpetation.

A simple answer to the question posed by this paper could be that a toxic waste is one containing any of the materials listed in the Annex to E.E.C. Directive 78/319 or any of the wastes referred to in Appendix B of the guidance memorandum circulated recently by our own Department of Environment. I think everyone will agree that such an approach is not only unhelpful but it would lead to considerable work and cost in locating, analyzing and licensing a very large number of wastes many of which are no more toxic or dangerous than garden soil. This is so because the use of analytical techniques would almost certainly confirm that at least one of the listed substances, and probably the majority, are present in all wastes generated.

Recognizing this difficulty, the Directive on Toxic and Dangerous Wastes stipulates that wastes should be regarded as such only when the concentration of one of the 27 listed substances constitutes a risk to health or environment. It is up to the responsible agencies to determine this risk in individual cases. The

Department's memorandum notes that local authorities will have a certain amount of discretion in deciding which wastes are toxic and dangerous. However, in fairness to the environmental officers responsible, their discretion will need to be backed up by some additional guidelines, or a detailed knowledge of toxicology, if they are to adopt a uniform approach to classifying wastes in accordance with the requirements of the Directive. The job is not going to be easy but perhaps a few suggestions as to possible criteria for assessing hazard would be in order.

Part of the process of evaluating risk involves predetermining the likelihood of exposure for humans and the environment. Because a chemical may be safe under one set of conditions but hazardous under another the evaluation must take into account the various uses, transformations, movements, distributions and deposits which a potential toxicant will be subjected to. Directive 78/319 does not exclude occupational exposure and so the risks to factory workers and those responsible for treatment, recycling and disposal could be considered part of the basis for deciding whether or not a particular waste is toxic or dangerous. In my view it would be justifiable to regard such personnel as a low risk so long is it can be assumed that they are conscious of the materials being handled and that they are properly supervised.

The first problem is to establish whether a waste contains a <u>significant amount</u> of the listed substance. By 'significant' we mean that the form and quantity of the chemical in the waste is such that under worst-case conditions i.e. maximum likely exposure for humans, or protected wildlife, deleterious effects will occur. Article 1b of the Directive is more concise but somewhat less specific in using the phrase 'constitutes a risk to health or environment'. This stage of the assessment is crucial because it is pointless to issue licences under Article 9 for wastes containing listed substances only as trace contaminants.

Often it will be possible to identify potentially hazardous wastes on the basis of the industrial process, raw materials and products but occasionally, where complex reactions occur, the precise composition of the waste may be difficult to predict. In such cases chemical analysis will be required. Where substances covered by the Directive are part of a manufacturing process the amounts present in the waste would generally exceed 0.1% wt/wt (or wt/vol.), a concentration which is regarded as the lowest significant amount by several of the marine dumping conventions. This can be a useful guideline when reviewing analytical data on waste composition. While it is not true to say that concentrations of less than 0.1% cannot be hazardous it is likely that lesser amounts are present mainly as background impurities and will generally be present only in the lower parts per million range.

Some measure of significance for concentrations of metals can be gained from the amounts present in natural media. Table 1 shows that of the eleven elements specified in Directive 78/319 all except tellurium are found in water, soil and mammalian tissue as well as in ingneous rocks. Average soil concentrations range from 30 parts per billion for mercury to 100 parts per million for chromium. Data of this kind are particularly useful in assessing the hazard of solid waste disposal on landfill sites because there would normally be little basis for concern where concentrations approach natural soil values.

In the U.K., a special waste under the Deposit of Poisonous Waste Act (1972) is defined, in part, as one which would cause death or serious damage to tissue when 5 cm^3 is consumed by a 20 kg child (reckoned to be the most vulnerable member of society). Assuming a waste density of 2g per cm^3 the allowable concentration of the most toxic substance present in a waste can be obtained by dividing the oral LD_{50} (lethal dose) by 5. Where human LD_{50} values are not available animal data may be used. As an example Table 2 gives estimates of acute dosages for ten metals listed in the Annex and the corresponding maximum percentage concentrations which may occur in a waste without the need for a special waste permit. These range from 0.3% for antimony to about 12% for mercury showing that, at least from the standpoint of direct effects on humans i.e. oral intake the 0.1% limit is a reasonable value. However, seven of these metals including mercury are cumulative poisons i.e. may be stored in human and animal tissues, and wastes containing less than 0.1% of these metals could be hazardous if the metals were present in soluble form. In such cases groundwater contamination could lead to indirect toxicity through bioaccumulation via potable water or the aquatic foodchain.

Therefore solubility data is often a pre-requisate for determining a significant level of contamination.

One approach, which can be used for many of the substances listed in the Annex to the directive, is to subject the waste to a leachability test followed by analysis of the leachate. The test is designed to simulate dissolution of chemicals by rainfall. In the United States safe concentrations are deemed to exist where the concentration in the leachate is less than100 times the drinking water standard. This criterion is particularly suitable for phenols, cyanides, chlorinated organics, the more common biocides and other synthetic compounds. Some difficulty may be experienced by local authorities in determining the standards for certain materials and in such cases outside advice should be obtained.

Leachability tests are also valuable in assessing environmental risks especially where wastes are disposed of in landfills. The standard procedure involves extracting one part waste with ten parts buffered acetic acid (pH 5) by stirring for 8 hours, settling, passing through a 0.45 micron filter and finally chemical analysis. Concentrations may be compared to published toxicity data or water quality objectives. The test may also be useful in assessing the potential hazard of mixed and complex wastes, where the composition is uncertain, if the leachate is subjected to a toxicity test with aquatic organisms. Chemical and pharmaceutical wastes are typical examples since in many cases a complete analysis is at best exceedingly costly and at worst impossible. The use of aquatic organisms is a practical and reliable indicator of environmental risk and, in the absence of relevant mammalian data, may be a reasonable guide to the status of the waste under Article 1. The rationale for this is that fish and other aquatic organisms are frequently more sensitive to chemicals than mammals. This is especially true for acute toxicity. It is not always true for substances which bio-accumulate such as mercury, PCB's and other organohalogen compounds. But aquatic organisms may also be used to examine accumulation potential and this can be an important test where synthetic water-soluble organic compounds are being considered for landfill disposal.

Recently our laboratory conducted tests with the freshwater crustacean Daphnia magna (a standard toxicity test species) to determine the toxicity of a typical metal sludge from a plating operation containing mainly copper and zinc. The sludge had been produced by precipitation with lime. Assuming that the acetic acid solution used for extraction would itself have some toxicity this was initially tested on its own. The filtered leachate was tested without further treatment and also after passage through a short column of artificial soil. As shown in the following table the leachate had a relatively high toxicity but this was reduced to near background following soil percolation showing significant resorbtion of the toxic substances present. Undoubtedly the leachate test tends to exaggerate natural leaching and waste management decisions based on these results should provide a wide margin of protection against groundwater contamination.

Toxicity of Metal Sludge to D. magna.

	24-hr. LC_{50}	Tu
A. Acetic acid solution	4.3%	23
B. Sludge leachate	0.35%	286
C. Sludge leachate via soil	3.2%	31

In order to assess the possible risks to fish and other organisms inhabiting adjacent streams, ponds or estuaries it is necessary to place limit values on toxicity data obtained from tests with simulated leachate. The test with Daphnia is an inexpensive, rapid and reliable measurement which should be particularly useful for wastes of doubtful composition or those whose status is uncertain using other hazard criteria. On the basis of our studies it seems reasonable to propose that leachates with less than 100 toxic units could be regarded as safe to aquatic organisms and, if this were the only hazard anticipated, licensing should not be necessary. This is a conservative figure because one must assume that non-hazardous wastes could be dumped on any landfill including those with poor retention characteristics. Leachates with more than 100 toxic units represent wastes which should be given special care while those more than 5000 toxic units may require additional treatment to reduce solubility. These provisional guidelines will be kept under review by I.I.R.S. and further testing is underway to obtain data on a wide range of waste types including domestic refuse.

From the discussion so far we can see that there are various ways in which toxic substances exert their effects and that hazard depends on the possibilities for contact, ingestion or inhalation and these, in turn, depend on the type of waste and method of handling and disposal. With solid wastes and sludges there are three categories of toxic materials which are of particular concern

A) Those with high acute toxicity (lethal with a single oral dose or yielding a toxic leachate)

B) Those which bio-accumulate and which may be leached by rainfall giving rise to chronic poisoning if drinking water is contaminated.

C) Carcinogenic substances for which safe levels of exposure are generally unknown.

Some guidelines have been given as to significant concentrations of substances in the first two categories which include metals, inorganic compounds, chlorinated hydrocarbons, most solvents, pharmaceuticals and biocides. The third group however requires special consideration because safe levels for most carcinogenic substances have not been determined. These include certain aromatic polycyclic compounds, chromium and nickel concentrates (mining). Wastes containing even small amounts of these materials should be subject to tight controls so that atmospheric and ground water contamination is minimized.

There are no ready-made answers to the question of what constitutes a toxic substance and this paper contains no surprises in this regard. Each waste generated will have its own chemical and physical characteristics and the possibilities available for its disposal will vary from industry to industry and place to place. Some guidelines have been given which should help to reduce the number of licenses under Directive 78/319 and assist environmental officers in evaluating risks. As experience is gained and test procedures improve better criteria will emerge. I.I.R.S. intends to keep these developments under review and looks forward to a close liaison with local authorities so that we can advise and assist where difficult cases present themselves.

TABLE 1. METAL CONCENTRATION IN VARIOUS NATURAL MEDIA (PPM).

	Igneous Rock	Dry Soil	River Water	Mammalian Blood Kidney	Kidney Ratio Water
As	1.8	6	0.6	0.34	0.6
Be	2.8	6	0.001	0.002	2
Cd	0.2	0.06	0.08	130	1600
Cr	100	100	0.00018	0.05	280
Cu	55	10	0.01	12	1200
Hg	0.08	0.08	0.00008	0.25	3100
Pb	12.5	10	0.005	4.5	900
Se	0.05	0.2	<0.02	2.1	105
Sn	2	10	0.00004	0.74	5.7
Te	0.001				
Th	9.6	5	0.00002		

TABLE 2. ESTIMATION OF SPECIAL WASTE STATUS (U.K.) FOR LISTED METALS.

Substance	Oral Dose mg/kg	Data Type	Limit Conc'n % Waste
As	2	Est. LD_{50} (M)	0.4 (C)
Be	20	No Effect (A)	4
Cd	10	Est. EC_{50} (M)	2
Cr	3	Est. EC_{50} (M)	0.6
Cu	16	No Effect (M)	3.2
Hg	60	Est. LD_{50} (M)	12 (C)
Pb	7	No Effect (A)	1.4 (C)
Se	2	Est. LD_{50} (A)	0.4 (C)
Sn	15	Est. LD_{50} (M)	0.3 (C)
Th	30	Est. LD_{50} (A)	6 (C)

M = Man A = Animals C = Cumulative

ex. McKee and Wolf. Water Quality Criteria 1963.

LANDFILL ASSESSMENT PRACTICE

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An Foras Forbartha.

INTRODUCTION

Sanitary landfilling is an engineered method of disposing of solid wastes on land in a manner that minimises environmental hazards and nuisances. In Ireland at present about 80% of all solid wastes from local authorities and the industrial sector is disposed by landfill methods. Landfilling is the most economical way of disposing of wastes but it does involve considerable expense in preparatory and completion works at the chosen site. The importance of a full site investigation study must be emphasised. An information circular has been published by the Geological Survey of Ireland in 1982 on Waste Disposal Sites, Geotechnical Guidelines for their Selection, Design and Management. A circular from the Minister of the Environment in October 1982 advised the local authorities on the provision of co-disposal sites for industrial and other wastes.

INVESTIGATIONS

Investigations leading to the assessment and development of controlled landfill would be carried out in stages:

1. Data collection and site inspection
2. Preliminary investigations
3. Drilling programme
4. Design and development stage

The site assessment procedure outlined above is a sorting out process in which in the early stages a number of alternative locations may be under consideration. Circumstances may not allow the separation of various stages and telescoping may be necessary.

DATA COLLECTION AND SITE INSPECTION

This stage is likely to consider a number of possible locations. Information as is available should be collected and analysed.

(a) Up to date 1:10560 and 1:2500 maps are needed.

(b) Geological data is available from Geological Survey of Ireland.

(c) Climatic data from the Meteorological Office.

(d) Estimated site capacity, proposed fill rates and estimated life span can be established by the local authority.

(e) Major water supply sources and private sources in the vicinity can be obtained from the local authority.

(f) Hydrometric data on nearby rivers is available from AFF, OPW or ESB.

Site inspection will clarify the relationship of the proposed site to nearby springs, streams, boreholes and surface water ponds. The measurement of water levels in boreholes and springs will aid in the interpretation of groundwater conditions beneath the site but it must be stressed that flow patterns inferred from a regional scale can give misleading flow directions and should only be used in conjunction with on site hydrogeology. The site's geographic location with respect to major waste producers along with haulage costs must be examined. The existence of unusual habitats for birds and other wild life should be noted. The impact of dumping activities on the visual amenity of the area from adjacent roads and nearby houses (no residential boundary should be within 200 m of the site) can, along with a critical examination of the existing infrastructure of roads, water supply and electricity, be assessed.

An essential component to the efficient management of a landfill is an adequate amount of cover material and a suitable source should be sought at an early stage.

PRELIMINARY INVESTIGATIONS AND DRILLING PROGRAMME

Once a particular location has been chosen as a possible landfill site the following surveys should be carried out:

(i) Topographic Survey: to provide in sufficient detail the basis for working maps/drawings of the area. The data would provide an accurate capacity of the site, the extent of cover materials required, statistics for the site development plan and the locations of roads, dwellings, rivers, etc.

(ii) Groundwater and Surface Water Survey: a water table map should be drawn from available water levels, in boreholes and springs; seasonal variations should be measured and flow measurements in streams taken at regular intervals.

(iii) Trial Pit Survey: trial pits should be excavated, where there are unconsolidated sediments beneath the floor of the site, to establish what type of sediments exist in the top 3 - 4 metres. The work should be executed and supervised in accordance with recognised codes of practice. A JCB may be used in dry sand pits but where the ground is wet or difficult it is essential that a tracked excavator should be used to cope with the terrain. A detailed log of sediments should be recorded, water entry levels noted and undisturbed soil samples taken for laboratory analysis. The various components in the sediments can be classified using sieve analysis; permeability, water content, bulk density, liquid limit and plastic limit measurements. In the pits where water is met a shallow well pump with a long (up to 100 m) distribution pipe should be used to determine the quantity of water in the upper 3 - 4 metres. The discharging waters must be diverted a distance away to prohibit recirculation of the water. The volume of suitable materials available for use as cover material is estimated.
Soils that can be ruled out for use as cover material include peat and highly organic soils since they are virtually impossible to compact. Available top soils should be noted and reserved for spreading to allow growth of vegetation when landfilling is completed.

(iv) Water quality survey: the composition of groundwater and surface waters in the vicinity of the site should be determined so that the effects if any of pollutants emanating from the landfill at a later stage can be evaluated. In rural areas, in particular, groundwater may already be contaminated by agricultural effluents.

An Foras Forbartha has assessed existing and proposed sites for local authorities over a number of years. The different types of sites investigated is outlined.

Existing Tips

At an existing tip site investigations are carried out to:

(1) assess the quantity, direction and rate of movement of leachate away from the refuse area,

(2) establish the water bodies, both surface and groundwater that could be contaminated,

(3) determine the quality characteristics of the leachate and

(4) recommend action for the protection of the environment.

A disused gravel pit site which contained an existing tip was studied by An Foras Forbartha.

Thirty five trial pits were dug to establish the sequence of sub surface strata beneath the site. A thin horizon of silts, clays, sands and gravels were encountered overlying an impermeable boulder clay. Drilling followed to confirm the existence and determine the thickness of the boulder clay along with the sequence below the clay. Sufficient data was obtained to confirm that the boulder clay forms a practically continuous layer beneath the gravel pit floor and in places comes very close to the existing surface. Water levels and direction of flow showed that groundwater emanating from the tip which was located at the uppermost end of the catchment flowed away from the tip in the thin upper horizon of sands and gravels and followed the direction of slope of the boulder clay. This water is perched by the impermeable boulder clay and emerges in surface drains on the floor of the pit where the boulder clay is at or near the surface. There was therefore no threat from leachate to groundwater in the area since the leachate is perched in the thin permeable deposits above the boulder clay and this leachate discharges into surface flow to collect in ponds on the site.

A comprehensive water quality survey of the surface and groundwater bodies in the area beyond the site showed that there was no contamination from the leachate beyond the site.

The study, confirmed that contaminated water from the existing tip is confined to the gravel pit floor where it emerges and collects in surface ponds. Because the leachate comes to the surface it can be monitored, collected, its effects calculated and remedial action taken.

Flood Plain Sites

At a flood plain site it is necessary to determine:-

(1) the water bodies that would be contaminated by leachate produced at the site.

(2) the quantity and quality of leachate produced along with the direction and rate of movement of that leachate away from the site,

(3) the assimilative capacity of the receiving waters, and to evaluate if these waters can, without harming the aquatic environment, accept the leachate, and

(4) the amount of new land, if any, that would be flooded as flood waters are diverted away from the site.

Flood plain sites were investigated to determine their suitability for landfilling with regard to the surface and groundwater resources of the area.

Trial pits were dug and at each site impermeable sediments existed beneath the flood plain. These impermeable sediments would act as a hydraulic barrier and restrict the percolation of leachate and thereby protect the groundwater resources. Leachate would discharge as surface runoff. It was recommended that toxic materials should not be tipped at these sites.

The control of leachate generation by staging and development, using individual cell units, catering for one year with controlled drainage would result in a maximum increment in the river water of 0.5 mg/ℓ. A surface drainage system was devised to divert any runoff from the lands above the site. A monitoring station would be incorporated to measure the quantity and quality of leachate discharging into the river. Excess leachate can be re-circulated on to the waste disposal area.

At flood plain sites:-

(1) the alluvial sediments which form the floor are generally composed of fine grained impermeable sediments which prevent infiltration and permit surface runoff;

(2) groundwater bodies are generally discharging to the adjacent river;

(3) water balance studies for the site will provide estimates of the quantities of leachate produced;

(4) by diverting surface waters away from the site leachate is only produced from direct recharge;

(5) the assimilative capacity of the adjoining river to dilute any leachate is calculated and a development plan has to be prepared which will minimise the leachate quantities;

(6) a monitoring system is needed to confirm the leachate production and a contingency plan must be prepared to provide for any excesses of leachate above the safe estimate;

(7) tipping should be done in the dry and this may involve the construction of a flood protection bund;

(8) toxic materials should not be dumped and

(9) the effects of landfilling on the remainder of the flood plain in particular at high water levels as new lands become flooded due to the diversion of floodwaters away from the tipping site needs to be evaluated.

Quarry Sites

There are a number of aspects which need to be investigated before a quarry site can be regarded as suitable for landfill development:-

(1) will there be an improvement in land use,

(2) the geology of the area and the availability of cover material,

(3) the occurences of surface water and how they will be affected by the landfill,

(4) the occurences of groundwater, whether the area is in a recharge or discharge zone, the existence and thickness of an unsaturated zone, the existence of impermeable sediments beneath the quarry floor, the direction and rate of movement

of leachate away from the site, the aquifers and groundwater users which would be contaminated by the location of the landfill.

(5) The relative levels of water bodies and an understanding of their relationships,

(6) locality, accessibility, adequate road network and visibility of site from houses in the area.

(7) Ecology, unusual wild life habitats should not be affected.

(8) Nuisances from fly away litter, birds, insects and rodents should not happen,

(9) the site should have an adequate capacity and life span to suit the needs of the local authority.

A number of sand and gravel pits were investigated to assess their potential as landfills.

Once the data from the preliminary investigation has been critically assessed and the site is still regarded favourable for landfill development a detailed drilling programme would commence. It would provide data on the geology and hydrogeology beneath the site and its immediate hinterland. Boreholes should be drilled around the site and downgradient of the site. Where there is bedrock directly beneath the site floor investigations will commence with a drilling programme.

The choice of drilling equipment is dependent on the nature of the materials to be drilled. A percussion rig should be used to drill in unconsolidated sediments and in fissured limestones. An air flush rotary rig drills efficiently in hard rock. In places a combination of methods may be needed. The starting diameter for drilling should be large enough to allow for a number of reductions i.e. start with a 300 mm bit and reduce from 250 mm to 150 mm.

A detailed descriptive log of the type, thickness, depth and water entry level should be maintained. Samples must be taken at intervals which will show the variations found. With percussion drilling the bailer should be used to test water quantities as they are met and with a rotary rig water quantities can be tested using the compressed air to discharge water from the bore into a drainage system with a v-notch to measure the discharged quantities.

The design of the permanent liner will depend on the individual borehole. A screen should be placed opposite water bearing strata to facilitate pump testing. Permanent liner may be of steel or PVC, the latter having the advantage of being less than 50% of cost of steel. The finished internal diameter should be large enough to allow for sampling and water level monitoring equipment.

Pumping tests, where there is a quantity of water, should be made and the observation boreholes should be used as monitors to determine the effects of pumping at distances from the pumped borehole. Where there is a lack of water, falling or rising head tests will provide data on the permeability of relatively impermeable strata. In impermeable strata water levels may take a long time to recover. Boreholes should be maintained as piezometers for continuous water level monitoring and they would also be used as water quality sampling points.

Where a confining layer is found it may be necessary to design for and drill both shallow and deep boreholes to determine the hydrogeological characteristics of the water bearing strata above and below the confining layer.

Problems Encountered in Drilling

The taking of undistrubed samples for coarse sediments is difficult but a U4 tube attached to a drilling stem will provide samples from the finer range.

Constant supervision of drilling is essential in particular when a rotary rig is used. The formations are penetrated so quickly that it will be necessary to stop and start drilling as each formation is assessed. Costings for this interrupted form of drilling should be incorporated into the drilling contract.

Health aspects of workers where drilling penetrates an existing tip needs to be stressed in the drilling contract. Tetanus and TABT injections are recommended and gas masks and protective clothing should be used. Strict warnings against smoking and handling the materials drilled from the tip should be given.

Drilling Contracts

A detailed drilling contract outlining the expected work programme including detailed data on drilling equipment, drilling logs, formation sampling, standing time and so on with itemised costings must be prepared for each job. Investigations may be of a sensitive nature and the contractor should be advised not to make any statements about the work but to refer all enquiries to the hydrogeologist or engineer in charge.

DESIGN AND DEVELOPMENT STAGE

The locating of a landfill at a site should not cause a deterioration in the quality of the environment. The design and development of the site is dependent on a detailed assessment of the hydrological and hydrogeological data made available by the investigations already discussed. The protection of the water resources in the area is of primary concern. Factors such as existing dwellings, distance from waste sources and unusual ecological habitats need consideration.

There are three general types of landfill.

(a) Sites where leachate must be collected and treated.

(b) Siteswhere leachate production can be reduced to the amount that can be absorbed within the site.

(c) Siteswhere the amount of leachate produced can be allowed to migrate through the geological structure beneath the site without detrimental effects on existing ground or surface water resources.

In all cases the priority of any development plan for a landfill site is to reduce the quantity of leachate produced to a minimum.

Protection of Groundwater Resources

About 25% of the total water supply in Ireland on average and over 90% in some counties is derived from groundwater sources. The Local Government (Water Pollution) Act 1977, makes it an offence to cause or permit any polluting matter to enter aquifers. The need to protect groundwater resources from pollution has prompted the GSI to formulate an aquifer zoning scheme presented in the information circular on Waste Disposal Sites,1982.

Leachate

Groundwater or infiltrating surface water moving through solid waste will produce leachate. A summary on the composition of leachates, Table 1, from 23 sites based on a UK study shows the variations found. Leachate production should be confined to direct recharge on the working area. All other waters should be diverted away from the site.

A water balance study can be made of the landfill site using data (rainfall, actual evapotranspiration and cumulative soil moisture defecits) obtainable from the Meteorological Office. Leachate quantities dependent only on site rainfall can be calculated using the following equation:

$$Pe = P - (R + Ep + S)$$

where Pe = percolation to water table

P = site rainfall

R = runoff

Ep - actual evapotranspiration

S = soil moisture defecit

Gas Production

The provision of an impermeable cap to assist surface runoff of rainfall away from the site and decrease the quantities of leachate produced within the refuse will effect the egress of methane gas from the landfill. In contact with oxygen methane is highly explosive. No problems arise, however, when landfill gas can be dispersed into the atmosphere. Relatively simple and inexpensive techniques can be employed to vent the gas in a controlled manner on site and minimise lateral migration. Gravel vents or gravel filled trenches should be incorporated into the final cover design to enable the gas to escape without creating any build up within the landfill itself.

Types of Waste for Landfill Sites

Landfill Co-disposal of Domestic and Industrial Wastes

Co-disposal is the disposal of industrial and other wastes including some hazardous wastes, in conjunction with household and commercial wastes on the same tip.

TABLE 1.

COMPOSITION OF LEACHATES FROM VARIOUS LANDFILL SITES IN THE U.K.

PARAMETERS (mg/l, except pH value)

	pH	COD	BOD	TOC	Cl^- (21)	ORGANIC-N	NH_3-N
LOWEST READING	6.2	66	< 2	21	70	ND	5
HIGHEST READING	7.6	11600	8000	4440	2777	155	730
AVERAGE	7.0	2094	1314	792	783	18.3	151

	NO_3-N	NO_2-N	ORTHO-P	Cr (20)	Mn	Fe	Zn
LOWEST READING	< 0.4	< .02	< .02	< 0.005	0.19	0.09	0.0:
HIGHEST READING	85	1.84	4.43	0.14	26.5	380	0.9
AVERAGE	4.6	0.23	0.47	0.04	4.31	75.2	0.2

Summary for 23 Sampling Stations (except where stated):

From WRC. TR 108, March 1979. "Leachate from Domestic Waste: Generation, Composition and Treatment, A Review:"

Research has shown that, while there may be variations in the quality of leachate at locations throughout a landfill, leachate from co-disposal sites where the ratio of industrial to domestic waste is controlled and managed is similar in composition to that produced from domestic and commercial wastes only. Thus, if the site is suitable for the disposal of domestic and commercial wastes it would also be suitable for the controlled co-disposal of certain industrial wastes.

Containment sites where leachate quantities produced are restricted or where the leachate is collected and treated are recommended for co-disposal. Landfill sites have a finite capacity for absorbtion of liquids and to ensure that this capacity is not overloaded, wastes with high liquid content should be severely restricted or else dewatered prior to disposal on a landfill site. Some wastes may be chemically incompatible with other materials and locations for disposal of such materials in a landfill should be chosen with care and records of the locations maintained.

The quantities of hazardous material would of necessity need to be a small proportion of the total and be in a relatively stable form.

Rodents and Insects

In a properly operated and maintained landfill, insects and rodents are not a problem. Good compaction of wastes and cover material is the most important factor in achieving vector control. A compacted earth cover of at least 150 mm in thickness, applied daily, is recommended for preventing the emergence of flies and for discouraging rodents from burrowing through the fill.

After Use of Site

Completed landfills have been used for recreational purposes, parks, playgrounds and golf courses. Parking, storage areas and botanical gardens are other final uses. An early formal decision of the final use of the land as a recreational area may help to overcome local objections to future site locations. Because of settlement and potential gas problems construction of buildings on completed landfills should be carefully evaluated.

Conclusions

Landfilling is the most common and cost effective means of eliminating solid wastes from our environment. Proper selection of landfilling sites and appropriate engineering design and operation will ensure that wastes can be disposed in a manner that avoids detrimental impact on our surface and sub-surface environment. Certain sites can be developed into co-disposal landfills to alleviate the urgent need for the safe disposal of industrial and some hazardous wastes.

THE SILLIOTT HILL TIPSITE,
KILCULLEN,
CO. KILIDARE.

DES.
~~D~~.T. O'CONNOR, B.A., B.AI., M.I.E.I.,
Acting Senior Executive Engineer,
Environmental Protection,
Kildare County Council.

SILLIOT HILL TIPSITE

Background.

During the 1970's there was a significant improvement in waste disposal standards throughout the country. This was brought about by public opinion no longer being prepared to tolerate the traditional dumps which Local Authorities had been operating throughout the years, in addition to Government and E.E.C. standards being improved and applied. When selecting sites for waste disposal facilities, it became necessary to ensure that sites were properly managed in order to reduce the impact of such sites on the immediate environment. Kildare County Council's commitment to better management of tipsites began in the middle 1970's when, in selecting a site near Sallins, specific commitments were given to nearby residents. These commitments were that the site would :-

(a) be manned continually in order to prevent scavenging, fires, etc.,

(b) employ a machine for use in covering and compacting the refuse full time.

This process continued throughout the late 1970's and allowed the Council to acquire further sites without the degree of opposition from local residents that might have been the case previously. During this period, in the late 1970's, the amount of industrial/commercial waste which was being generated increased throughout the country and this resulted in substantial quantities of this type of waste being deposited at Kildare County Council's landfill sites. At this time too, the realisation of the potential threat to groundwaters from landfill sites was becoming more clearly identified. Pressure was also mounting for the provision of co-disposal tipsites which would be capable of receiving some hazardous wastes on conjunction with industrial and normal domestic refuse. Therefore, in addition to proper management of sites overground the Local Authority was also obliged to assess the impact on underground water resources and subsequent surface waters.

The Site.

This site at Silliot Hill (Fig. 1) was identified as a potential landfill site for the following reasons:-

1. Size - 7.9 hectares with approximately 600,000 cu.m. capacity.

2. Location - On the N9 convenient to Naas, Newbridge, Kildare and approximately 30 miles from Dublin.

3. Accessability - Good road network serving the site.

The site was a partially worked out sand quarry. It was identified as a potentially suitable site for a co-disposal facility and for this reason, it was necessary to undertake a hydrogeological assessment of the area to assess the threat to ground waters and in particular to assess any potential threat to the River Liffey, the nearest point of which is approximately 1 mile from the site. Clearly, any potential threat to the river would have to be assessed in view of its importance from the point of view of water abstraction and its various other beneficial uses, such as angling and other leisure activities.

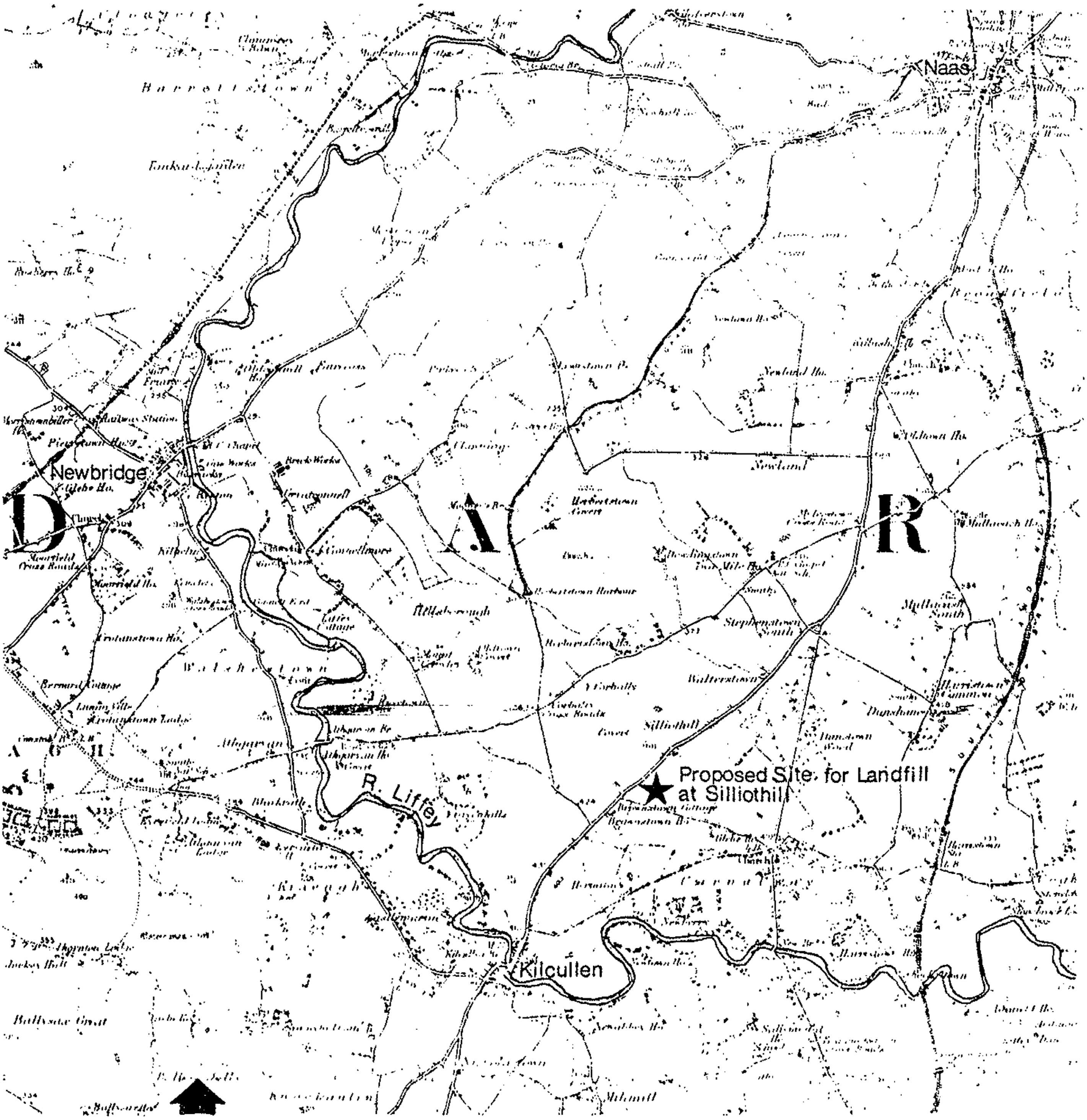

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FIG. 1 LOCATION OF SILLIOTHILL

The Investigation.

The site investigation was commissioned principly to establish the geology and hydrogeology of the area in and around the proposed landfill and to assess the risk, if any, of polluting ground water and surface water as a result of using the site as a co-disposal tipsite. An Foras Forbartha carried out the investigation during the period 1982/1983. Three boreholes were drilled, in addition to a number of trial pits, in order to assess:-

(a) the type and thickness of the unconsolidated settlements underlying the site,

(b) the direction and rate of groundwater flow.

The results of the analysis carried out by An Foras Forbartha indicated that :-

(a) the direction of groundwater was towards the River Liffey as indicated in Fig. 2,

(b) the Brownstown ridge on which the site is located contains a "minor aquifer" not used for human consumption.

The report concluded that the site was broadly suitable as a co-disposal facility. Should it be used as such, a clay-liner was recommended for the site in order to contain any toxic leachate which might be generated. The geology and hydrogeology of the area indicated that should there be an escape of toxic lechate from the site, that the effect of this would not be significant on the water resources in the area. Given that there is not, nor is there likely to be any water abstraction from the groundwaters through which any lechate would travel and that the type of sub-strata and the attenuation processes available

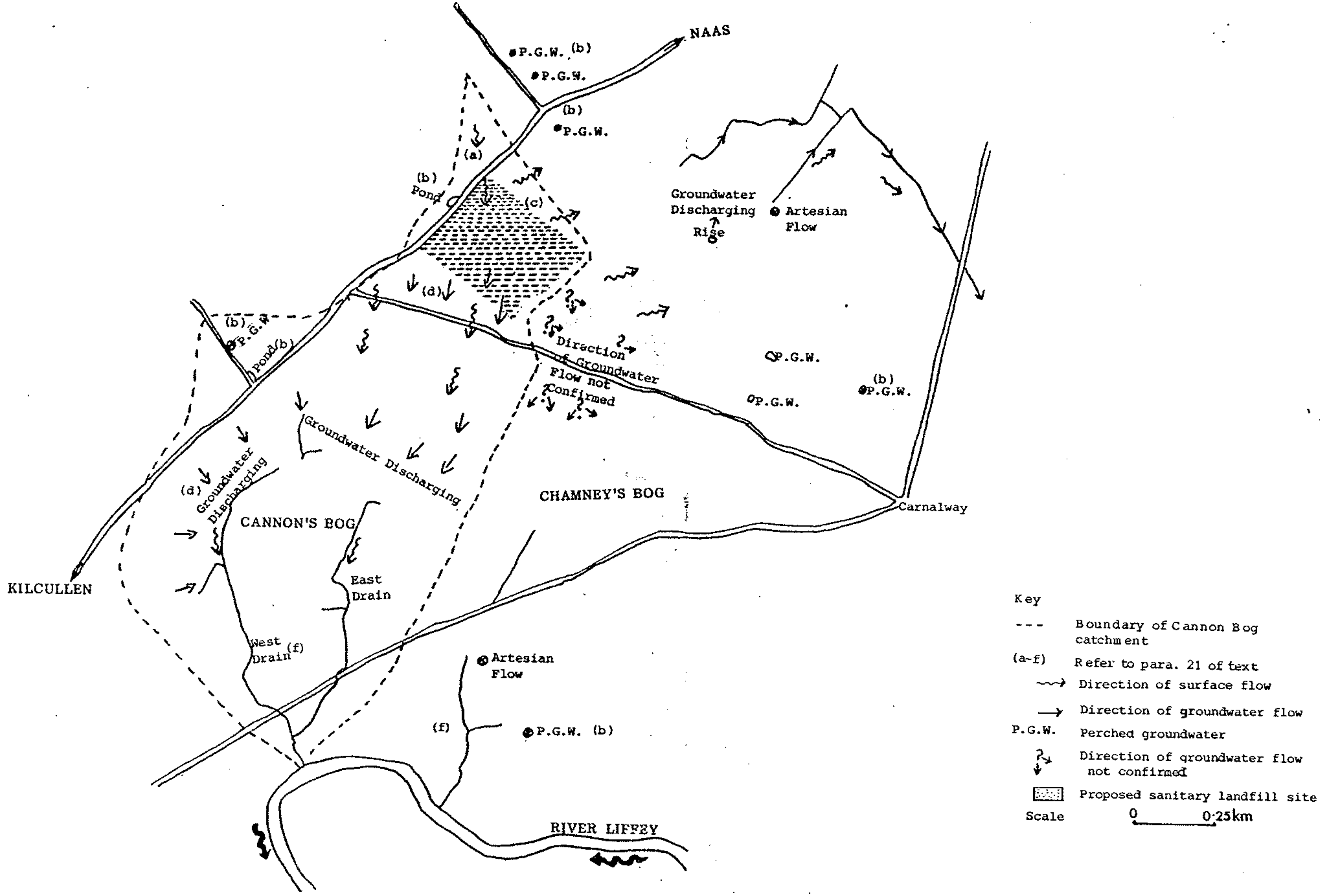
NAAS
P.G.W. (b)
P.G.W.
(b)
P.G.W.
(a)
(b)
Pond
(c)
(d)
Groundwater
Discharging
Rise
Artesian
Flow
(b)
P.G.W
Pond(b)
Direction
of Groundwater
Flow not
Confirmed
P.G.W.
P.G.W.
(b)
P.G.W.
Groundwater Discharging
(d)
Groundwater
Discharging
CHAMNEY'S BOG
CANNON'S BOG
Carnalway
KILCULLEN
East
Drain
West
Drain
(f)
Artesian
Flow
(f)
P.G.W. (b)
RIVER LIFFEY
Key
Boundary of Cannon Bog catchment
(a-f) Refer to para. 21 of text
Direction of surface flow
Direction of groundwater flow
P.G.W. Perched groundwater
Direction of groundwater flow not confirmed
Proposed sanitary landfill site
Scale 0 0·25km

FIGURE 2

through it, would have the effect of diminishing the strength of any lechate, it was concluded that no threat existed to the catchment. Therefore, although the site is relatively close to the Liffey, the hydrogeology of the area plus the dilutions available in the river, indicated that no threat to the Liffey existed. Sampling was carried out at eight and ten locations in 1982 and 1986 respectively. The surveys included analyses for physico-chemical and metal determinands. The former included: temperature, B.O.D., conductivity, pH, ortho-phoshpate, oxidised nitrogen (nitrate + nitrite), ammonia, alkalinity and chloride and the latter incluced: copper, lead, zinc, iron, manganese, cadmium and chromium. The results of these measurements are presented in Tables 1 and 2 and the sampling locations are given in fig. 3.

The results of the sample analyses indicate that there has been no change of an adverse nature in the water quality at the points sampled in both 1982 and 1986. At the three additional points sampled in 1986 (BH_1, BH_2, and BH_3) the data indicate unpolluted conditions with the exception of elevated oxidised nitrogen in the case of sampling point BH_2, which is most likely to have originated in agricultural practices, such as fertiliser spreading.

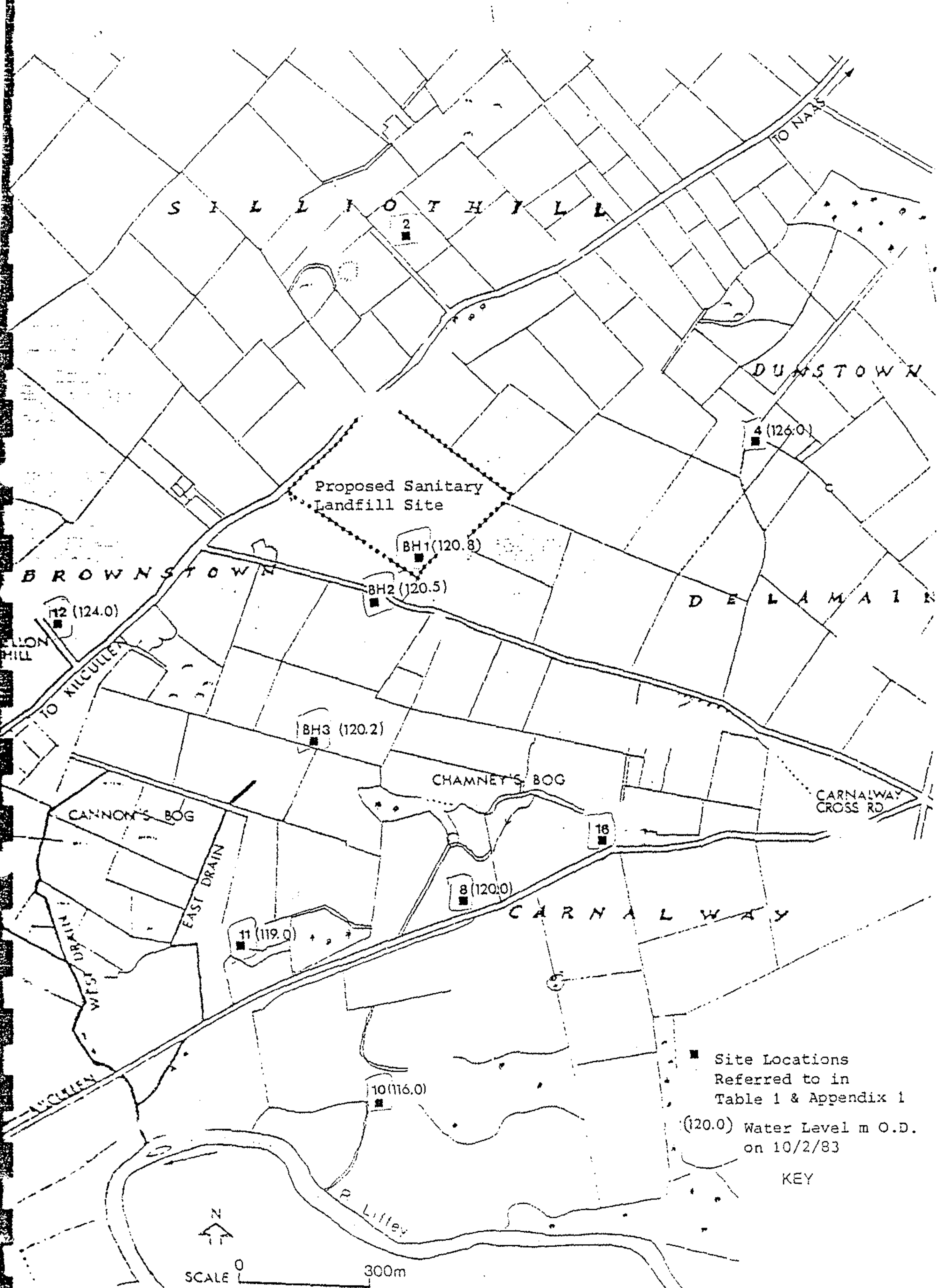

FIG. 3 Locations of Sampling Stations for Water Quality Samples, March. 1986.

TABLE 1

Results of Analyses of Samples taken at Proposed Landfill Site, Silliothill, Co. Kildare - 25 November, 1982

Parameter (Site Number)	Sample Number 2(B)	4(B)	16(D)	8(B)	10(B)	11(D)	12(D)	Trial Pit C
Temp. ^{o}C	7	9	8	8	7	8	8	9
BOD mg/ℓ	0.7	1.1	45	1.2	1.8	1.7	1.0	1.5
Conduct. µS/cm	660	590	870	520	660	580	490	740
pH	7.4	7.6	7.9	7.8	7.4	7.7	7.7	7.4
Ortho.P mg/ℓ P	0.003	0.031	2.3	0.06	0.01	0.08	0.01	0.02
Oxid.N mg/ℓ N	2.2	2.0	3.3	1.1	0.6	16.4	0.3	9.6
Ammon. mg/ℓ N	0.01	0.02	18.7	0.05	0.01	0.05	0.04	0.04
Silica mg/ℓ Si	3.5	5.9	7.2	6.5	4.2	4.9	3.2	3.7
Alk. mg/ℓ $CaCO_3$	338	318	296	280	380	228	276	374
Chloride mg/ℓ Cℓ	11	9	67	7	13	16	7	16
Copper mg/ℓ Cu	0.011	0.018	0.015	0.022	0.005	0.007	0.013	0.006
Lead mg/ℓ Pb	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.005	<0.005	<0.005
Zinc mg/ℓ Zn	1.33	1.21	1.33	0.12	<0.05	0.3	0.46	0.08
Iron mg/ℓ Fe	0.09	0.09	1.0	2.37	0.05	0.24	0.17	1.47
Manganese mg/ℓ Mn	0.005	0.007	1.05	0.021	<0.005	0.014	0.009	0.225
Cadmium mg/ℓ Cd	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chromium mg/ℓ Cr	0.049	0.047	0.049	0.01	0.01	0.028	0.033	0.01

B = Borehole. D = Dug Well

TABLE 2

Results of Analyses of Samples taken at Proposed Landfill Site, Silliothill, Co. Kildare - 12th March, 1986.

Parameter (Site Number)	Sample Number									
	2(B)	4(B)	16(D)	8(B)	10(B)	11(D)	12(D)	BH1 (B)	BH2(B)	BH3(B)
Temp. °C	7.5	9.5	7.5	7	6.0	9	8	8	10.5	10.0
BOD mg/ℓ	0.5		11.1	1.3	0.5	0.9	1.1	2.0	1.6	0.5
Conduct. μS/cm	670	640	860	520	700	680	520	290	760	610
pH	6.8	7.0	7.37	7.44	6.86	7.0	7.12	7.27	6.88	6.98
Ortho.P mg/ℓ P	0.01	0.024	0.875	0.013	0.018	0.02	0.01	0.02	0.008	0.053
Oxid.N mg/ℓ N	1.9	2.5	0.14	0.02	0.56	2.7	0.68	0.02	6.4	2.6
Ammon. mg/ℓ N	0.005	0.01	15.4	0.005	0.02	0.04	0.005	0.07	0.005	0.01
Silica mg/ℓ Si	3.55	6.0	7.25	4.35	4.2	3.8	2.75	1.35	4.05	4.15
Alk. mg/ℓ $CaCO_3$	346	484	328	296	382	336	276	182	372	328
Chloride mg/ℓ Cℓ	11	12	61	5	14	17	13	12	27	17
Copper mg/ℓ Cu	0.014	0.006	<0.005	0.005	<0.005	<0.005	0.008	<0.005	<0.005	0.008
Lead mg/ℓ Pb	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009
Zinc mg/ℓ Zn	0.112	0.031	0.012	0.128	<0.005	0.015	0.006	0.01	0.06	0.060
Iron mg/ℓ Fe	0.016	0.15	0.26	4.75	0.05	0.04	0.08	3.10	0.05	3.5
Manganese mg/ℓ Mn	0.017	0.046	1.12	0.65	0.014	0.010	0.013	0.92	0.03	1.87
Cadmium mg/ℓ Cd	<0.0002	<0.0002	<0.0002	0.0004	0.0005	<0.0002	<0.0002	<0.00096	<0.0002	0.0194
Chromium mg/ℓ Cr	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

B = Borehole. D = Dug well

Site Practice.

The site is open six days a week from 8.00 a.m. to 6.00 p.m. Later evening hours are worked during the Summer months. There is 1 caretaker on site whose function in addition to directing waste to correct locations on site, also includes the documenting of loads entering the pit, both from the Councils own domestic refuse collection service and from the commercial sector which uses the tip. Covering material is readily available on site and compaction of refuse and spreading of covering material is effected by the use of a Bomag 401 landfill compactor, which is hired onto the site. The use of the purpose built landfill compactor has the effect of prolonging the life of the tipsite by achieving a high rate of compaction, and allowing for rapid spreading and covering of waste.

One of the major problems in operating the site is the fact that sand extraction is still continuing. This has the effect of not allowing the Council to operate in precisely the sequence of phasing that it would like, as it is necessary to allow both refuse disposal and sand extraction to operate side by side. There are the usual problems encountered on tipsites such as papers blowing from lorries as they tip their loads, the problem of gulls, and occasional problems of smells resulting from certain types of waste being deposited. Occasional assistance from other sections of the Council is required to clean papers, etc., and at present the Social Employment Scheme is being used to help in this regard. Vertical standpipes are used to release waste gases to the atmosphere. It would not be economic to attempt to utilise these gases as an energy source.

The Council does not, in general, accept toxic and hazardous waste.

However, a pragmatic approach is adapted regarding the acceptance of wastes other than those obviously non-hazardous. Agencies such as An Foras Forbartha or the I.I.R.S. are contacted for specialists advice and their recommendations on a particular item of waste are taken into consideration when accepting or rejecting any particular waste.

There is routine sampling of sludges, to ensure compliance with the Council's requirement and no used barrels of any kind are accepted without prior investigation.

Cost.

The initial establishment of the site incurred significant expenditure on development with substantial movements of topsoil, covering material, etc., being necessary.

In addition, an adjacent house was purchased and acceleration/deceleration lanes were constructed on the N9 to facilitate traffic movements into and out of the site. The establishment costs to date are approximately £160,000, which includes the restoration of the phase I area by topsoiling and seeding. Th expenditure is funded by way of subsidised loan.

The site has a capacity of approximately 600,000 cu.metres, which was estimated to give a 5 - 6 year life span. The experience to date would indicate that the overall remaining life of the site, given the current level of tipping will be approximately 4 years.

The site is receiving the domestic waste from approximately 12,000 houses in County Kildare and approximately 36,000 tons of commercial/industrial waste, principally from the Dublin area per annum.

Assuming a domestic load of 13,000 tons per annum and a commercial/industrial load of 36,000 tons per annum, the unit operational costs * are as follows (excluding capital repayments) :

Total cost per tonne of waste accepted £1.79 per tonne.

Total cost per tonne of domestic waste £6.76 per tonne or £6.15 per household. (Assumes 1.1T of waste per household per annum).

It should be stressed that, as there are no weighbridge facilities on site, these are estimated unit costs.

* 1985 costs

The Future of the Site.

The site is rented from the landowner, who operates the sand extraction on the site. Upon completion of tipping, the site is to be restored to agricultural use, and returned to the landowner. This is to be achieved by placing a layer of topsoil on top of the site and by whatever tilling etc., is required for the particular agricultural use anticipated.

Monitoring of water quality in the boreholes will continue during and after the lifetime of the tipsite. This information, in addition to its usefulness in monitoring the particular site should also be of benefit in accumulating information on the effects of waste disposal on groundwaters in general.

International Association of Hydrogeologists (Irish Group)

Seminar on Waste Disposal Sites

The Portlaoise Landfill Site

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26 Upper Mount Street, DUBLIN 2.

The Portlaoise Landfill Site

Site Investigation and Management

1. SITE DESCRIPTION

The Portlaoise landfill is the main waste disposal site in County Laois and is located mid-way between Portlaoise and Mountmellick. It is a cutaway bog site, bounded on two sides by roads, with a large area of bog (natural and cutaway) available for expansion of the site to the north (figure 1).

Use of the site for waste disposal started when the Council bought about 0.5 hectare of land in 1959 and a further 5 hectares was purchased in 1966, at which time it was made the sole site for Portlaoise and Mountmellick. By 1976 it had become a central tip for the County and in 1979 it was proposed, in the Council's "Draft Plan for Waste Disposal", as a site to serve the whole of Laois. A large area adjacent to the existing site was purchased in 1981 for future use. The Council then commissioned an investigation of the site to assess its suitability as a sanitary landfill site with regard to hydrogeological factors.

2. SITE INVESTIGATION

A proposal to determine the geology beneath the site, the hydrogeological characteristics of the formations and the possibilities of groundwater contamination from the landfill was drawn up, accepted and carried out. The work was completed in a period of two months.

2.1 Borehole Construction

Five boreholes were drilled at locations shown in figure 2, 2 of these were on the existing landfill and the other 3 on cutaway bog. All of them were drilled through superficial deposits and 15 metres into bedrock. The sequence of strata that were encountered was as follows :-

landfill	$\leq$	5 m
peat	$\leq$	1.7 m
glacial drift	$\leq$	8 m

Carboniferous limestone (dark shaley limestone)

The drilling method was hollow-stem continuous flight augering through the superfical deposits and water flush core drilling in the bedrock.

After testing, 50 mm diameter plastic casing were installed in each of the boreholes. The limestone was grouted off in boreholes 1 and 4 and perforated casing was installed at the level of the base of the overburden. In borehole 3 perforated casing was installed in the landfill and boreholes 2 and 5 were left open into the limestone. Steel casings were installed at surface to protect the plastic casings. Details of borehole construction are given on figure 3.

2.2 Sampling and Testing Procedures

Undisturbed samples of the glacial drift were taken at 1.5 metre intervals. Standard penetration tests (at 1.5 m intervals) and falling head tests were also done in some of the superficial deposits. Packer tests to determine permeability were done in the limestone bedrock (figures 4 & 5). Groundwater levels were recorded, and ground and surface water samples were taken for analysis.

2.3 Test Results

Standard penetration tests done in the glacial drift gave values that were mostly greater than 50 indicating that the material was very dense (sands) or hard (clays).

Falling head tests were carried out only in silty and sandy strata because gravelly clay that was drilled was observed to be effectively impermeable. Transmissivities were calculated from residual head and time data; these were in the very low range 0 to 0.14 m^2/day.

Permeability values determined from the packer tests were mostly less than 10^{-8} m/s. The patterns of flow rate, or water loss, with increasing and decreasing pressure were interpreted as a reduction in permeability as fissures were sealed and some "back flow" occurred as pressures were reduced.

2.4 Conclusions from Site Investigation

The glacial drift is almost impermeable, owing to its clay matrix. The limestone bedrock too was found to be effectively impermeable. It was concluded that, in the area under investigation, there was no possibility of groundwater pollution, and that leachate from the landfill would emerge near the base of the tip and discharge into surface streams. Chemical analyses confirmed these conclusions. From water level measurements it was concluded that leachate would seep out at the northern end of the tip.

2.5 Site Management

Access and Security

Access to the site is from a minor road so there is no possibility of obstruction on the Portlaoise to Mountmellick road and boundary fencing was erected at an early stage alongside the minor road; this is the only side from which access is possible. Surface ditches around three sides of the site drain runoff to the south. A small shelter belt of conifers obscures much of the site from the major road.

Operation

The site is open 7 1/2 hours a day, six days a week, during which time a full-time operative is in attendance. The waste is not buried in cells but is spread and compacted in the familiar "foreset" configuration by a CAT D 5. When sufficient waste has been deposited in any area, topsoil is placed and spread on the waste. The Council have adopted a policy of tree planting to landscape the completed landfill and in 1985 a total of 2000 trees were planted.

Fire Hazard.

There is no provision for gas venting in the landfill but gas is not a problem, and does not fuel combustion within the landfill. Burning waste at the surface was a problem at times in past years and when the wind direction was unfavourable smoke caused a traffic hazard on the nearby road.

"Processing" of Wastes

The dumping of animal carcases at the roadside near the entrance was a serious problem around 1980 but that was overcome when of two knackeries were established at a short distance from the landfill. The site is now free from the objectionable aspects that inevitably follow from the practice of the disposal of animal carcases. Consequently the possibility of nuisance from vermin has been much reduced.

Metals are separated and a proportion of these are taken away for processing as scrap in Mountmellick.

In short, the condition of the site is now much more acceptable than at the time of the site investigation when it was reported to be environmentally unpleasant as a result of unauthorised dumping along the road, frequent fires, vermin and the processing of carcases.

Acknowledgement

Minerex Ltd. is grateful to Mr. D. O'Riordan, County Engineer, Laois Co. Co. for his permission to present this paper and to Niall Sweeney and Willie Walsh, of the Sanitary Services section, for information that is given in the paper.

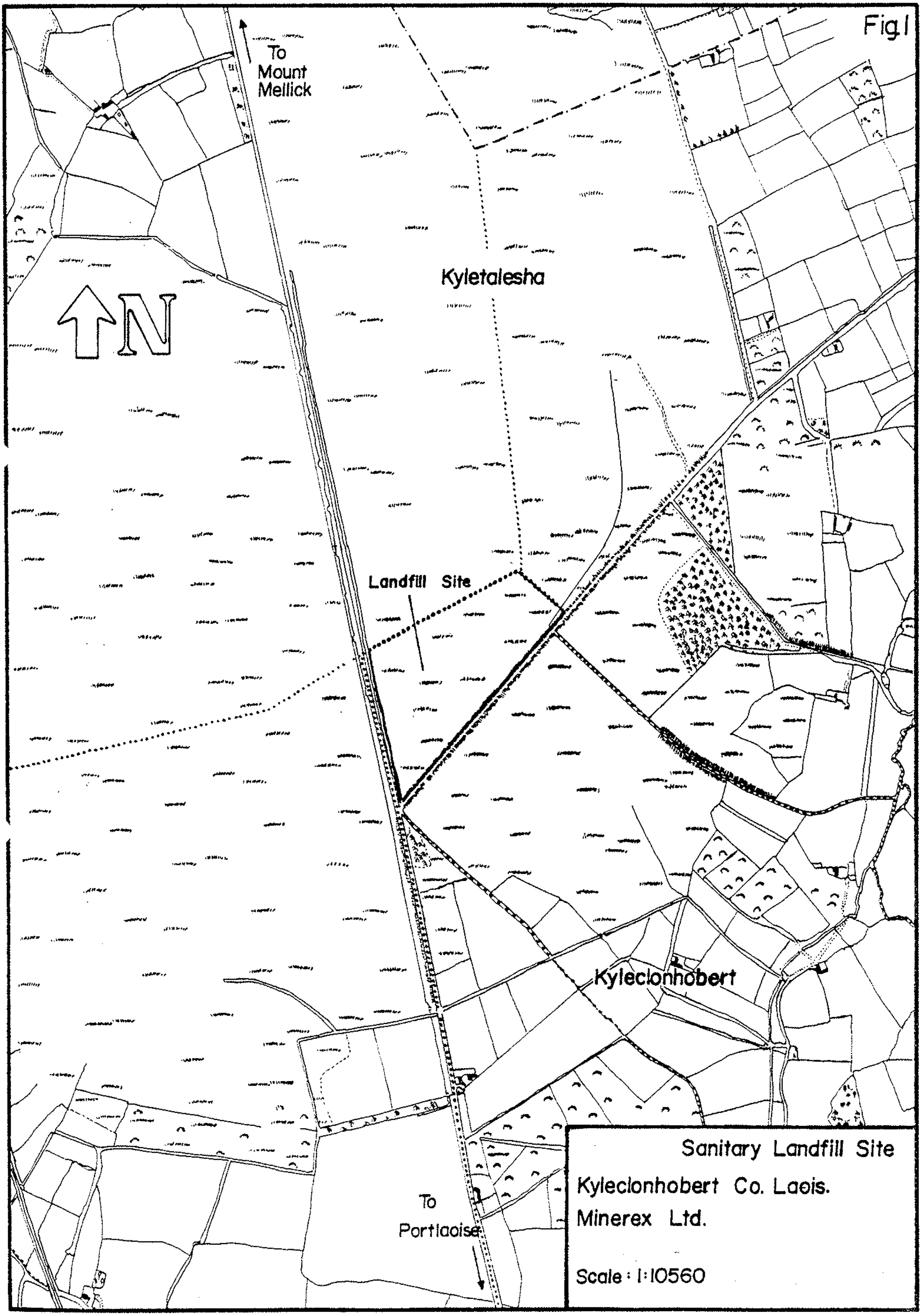
Fig.1
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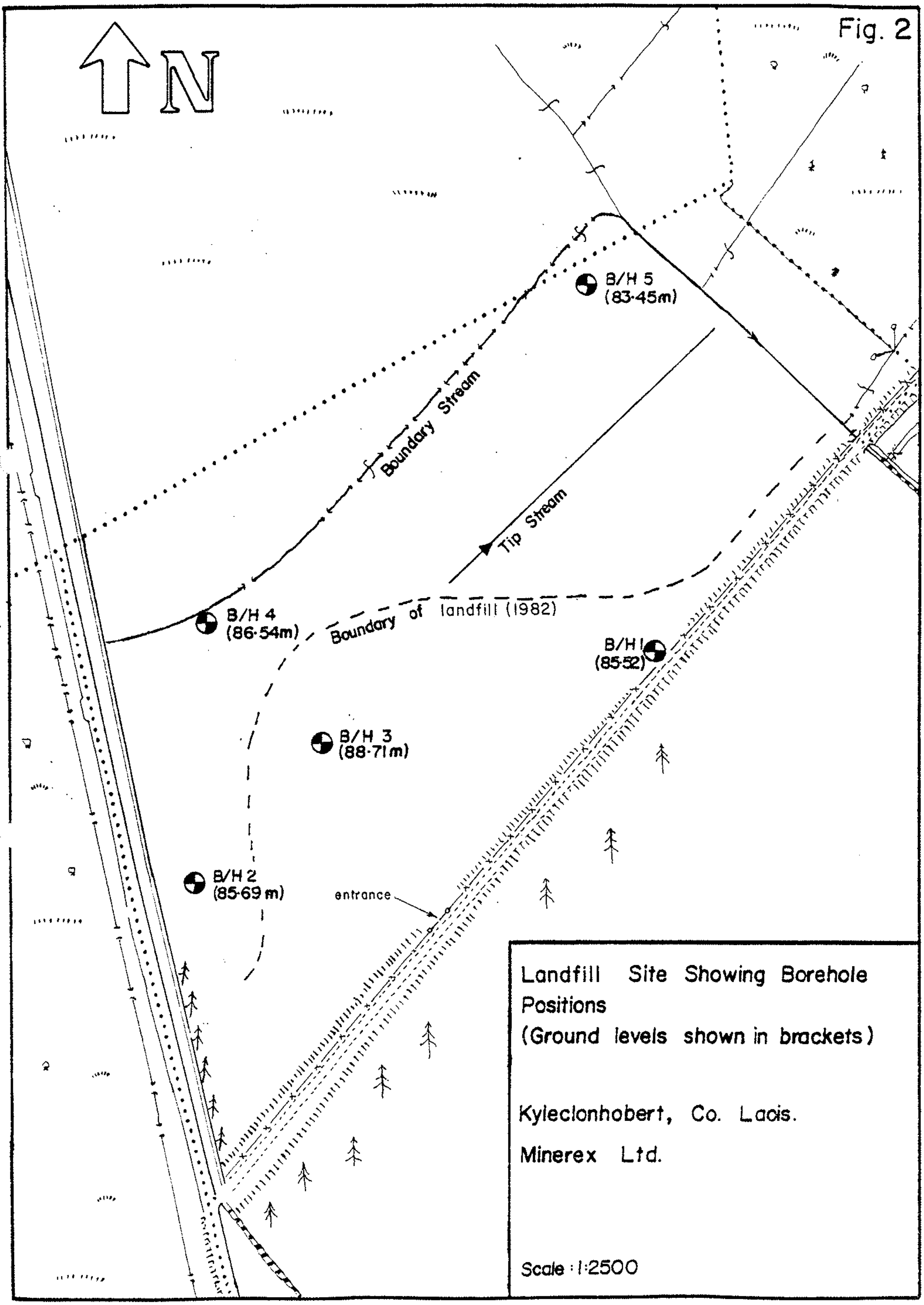

Landfill Site Showing Borehole Positions
(Ground levels shown in brackets)

Kyleclonhobert, Co. Laois.

Minerex Ltd.

Scale : 1:2500

Fig. 3 Profiles showing Borehole Installations.

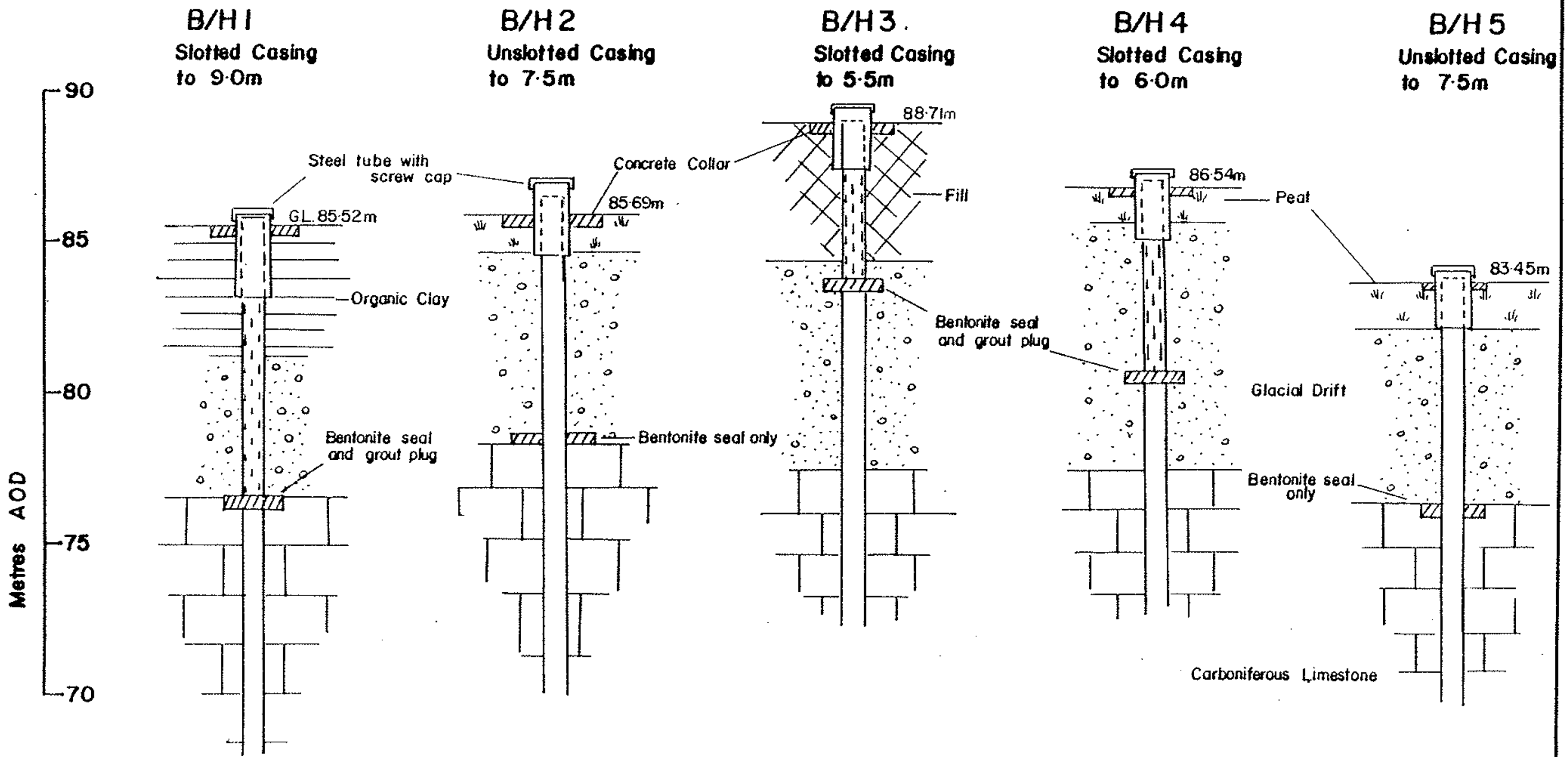

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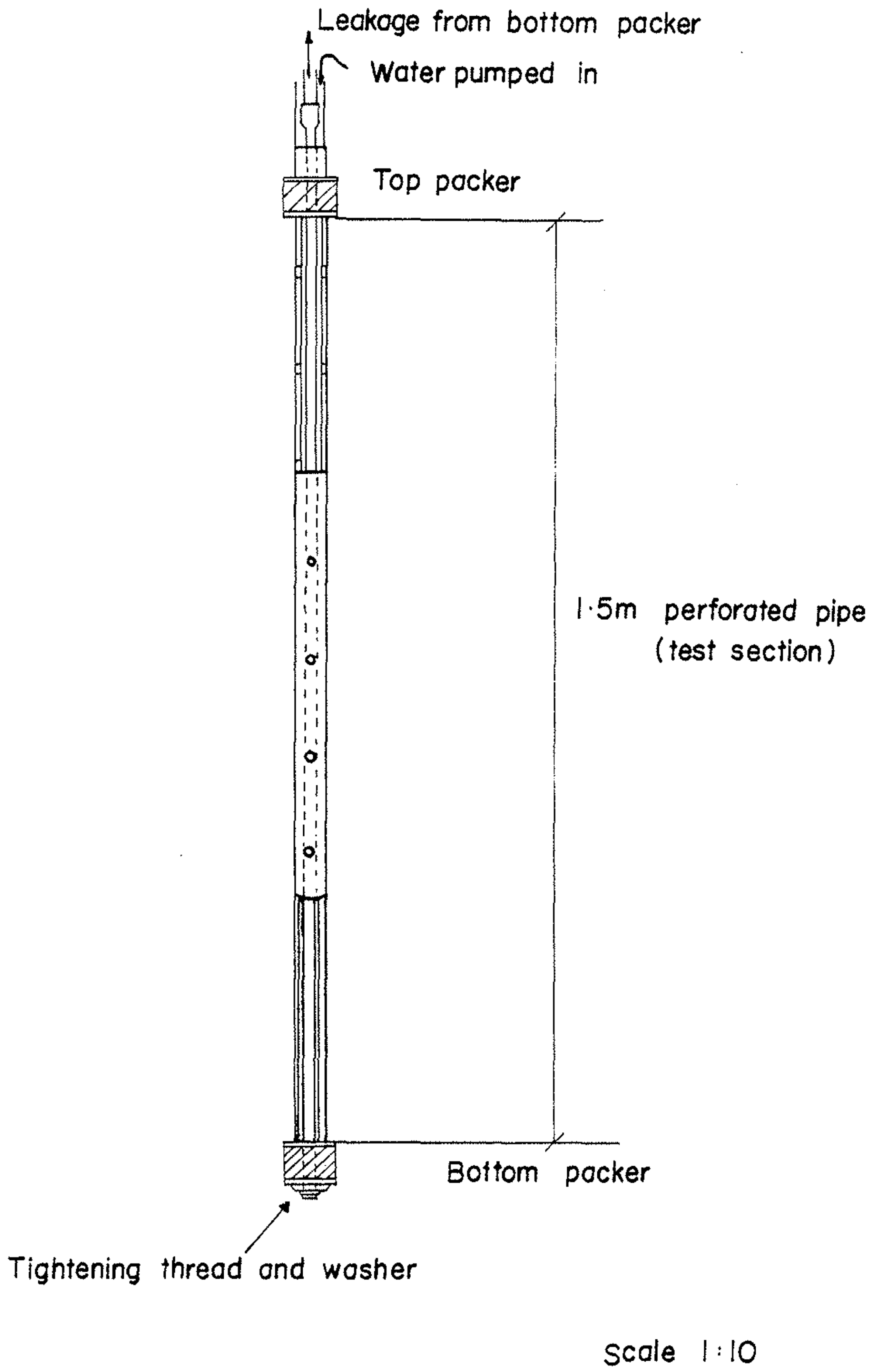
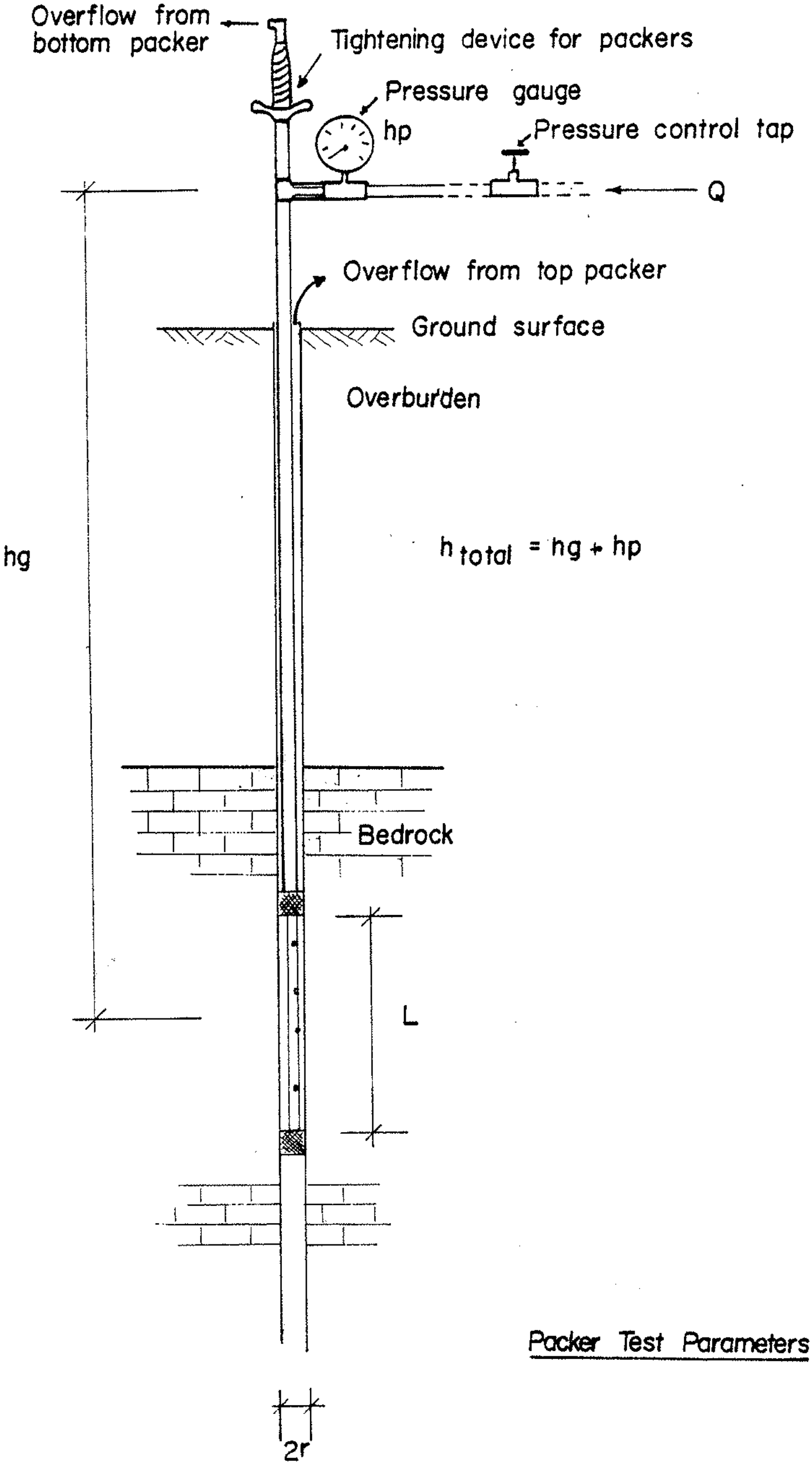
Fig. 4



Details of Double Packer Apparatus

Fig. 5



Packer Test Parameters

ASSESSMENT AND PREPARATION OF A LANDFILL IN SOUTHERN ENGLAND

By Keith Knox, Cleanaway Ltd.

ABSTRACT

The paper describes a clay-lined landfill, recently opened in a former sand and gravel quarry in southern England. Hydrogeological assessment, site design concept, preparatory works and environmental control are discussed.

Glacial sands and gravels overlie several metres of low permeability tertiary clay, which in turn overlies cretaceous chalk, a major regional supply aquifer. Groundwater in the sands and gravels, while not abstracted for drinking purposes migrates to small streams to the north and south. These in turn feed a river which is abstracted for potable supply. Because the proposed waste inputs included both putrescible and Special wastes it was necessary to engineer the site so as to contain any leachate produced.

In order to reduce leachate production to a minimum the site is being filled in five cells, sized using water balance calculations.

The environmental control programme incorporates leachate level and quality monitoring, surface water quality monitoring, gas monitoring and may include some groundwater monitoring.

Contingency plans for leachate disposal have been prepared.

HYDROGEOLOGICAL INVESTIGATIONS OF BELFAST'S NORTH FORESHORE WASTE DISPOSAL SITE

by

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I INTRODUCTION

1.1 The North Foreshore Tip is located at the head of Belfast Lough, on the northern shore of the estuary of the River Lagan (Fig.1). Tipping takes place on the mudflats between High and Low Water Marks and this land reclamation by infilling with domestic, trade, and industrial wastes has been practised since 1958.

1.2 During the 1960s the roads authority acquired some 324 hectares of land on the foreshore to build a motorway out of Belfast. Not all of the land was required for the road so 47 hectares on the seaward side was leased to Belfast City Council, at a nominal rent, for use as a waste disposal site. The site is now Crown land owned by the Department of the Environment for Northern Ireland which is responsible, inter alia, for planning control and water pollution control. In 1979 the DOE agreed to lease another 21 hectares of the foreshore land when the City Council agreed to accept waste from two other Borough Councils so the increased area should provide disposal facilities for 10 to 15 years from that date.

1.3 The tip operated by Belfast City Council now serves the general needs of three Councils representing a total population of almost 400,000 people and accepts special wastes from many others. Between 700 and 1000 vehicles a day bring in about 3000 tonnes of domestic refuse per week. In addition about 1000 tonnes per week of civic amenity waste, litter and street sweepings are disposed of plus about 6000 tonnes per week of industrial waste. Liquid (less than 1500m^3 per annum) and special wastes are subject to co-disposal at the site by means of separate excavation and disposal within the older refuse mass.

1.4 Conditions imposed on the tipping operation included providing a 76m wide 'inert' strip of land between the tip area and the motorway, and in summer time the infilling is to be carried out at the seaward side of the site, at maximum possible distance from the road.

1.5 Since 1974 the tip has been progressively built out into the estuary by forming cells of 5 to 6 hectares (Fig.2) using bunds of inert material such as quarry rubble or demolition waste. Each cell is filled with refuse and covered up to an initial height of 12ft (3.7m) above O.D. or about 1m above high tide level. A subsequent layer of covered waste takes the cell to a final authorised height of 22ft (6.7m) above O.D..

1.6 In the early stages of each bunded cell it is a lagoon of sea water which is filled as quickly as possible to above the standing water level and covered using imported soil. The basal layer of refuse in the tip is therefore saturated with sea water from the outset.

1.7 After-use of the site has not yet been decided upon so levels and contouring are not finalised. However, either industrial development or open space are the most likely uses. In the meantime natural vegetation has been allowed to recolonise large areas of the site and experiments are being carried out into potential biomass production.

II REASONS FOR HYDROGEOLOGICAL INVESTIGATIONS

2.1 Residents of the area inshore from the motorway have complained about unpleasant odours thought to be associated with the waste disposal site over the years. The smells and complaints peaked during the exceptionally warm summer of 1983: hence it was decided to investigate possible sources of the odours which included the tip and various sewage works outfalls in the vicinity.

2.2 Messrs Cleanaway Ltd of Rayleigh, Essex were appointed as consultants to carry out an appraisal of the problems and gas detection surveys were carried out by the Industrial Science Division of the Department of Economic Development. The following odour sources were identified:-

(i) seeps discharging from the landfill at low tide

(ii) anaerobic foreshore muds

(iii) the Shore Road drainage ditch

(iv) the Whitehouse sewage treatment works

and (v) the No.2 Belfast Pumping Station settlement ponds.

The seeps from the landfill seemed to be the main source, however, and it was concluded that each rising tide invades the landfill through the permeable bunds bringing a fresh 'charge' of sulphates (typical level in sea water 2650mg/l) which would be reduced by bacteria under the anaerobic conditions pertaining within the tip, resulting in hydrogen sulphide being released through the bunds as the tide falls.

2.3 It was also recommended that drilling investigations of the tip and the sediments beneath it should be carried out, with the boreholes being lined and retained to allow monitoring of water levels and sampling of the leachate over a period of time. It was envisaged that the monitoring programme would comprise two distinct phases:-

(a) initial assessment

and (b) long term surveillance

The initial assessment was to involve frequent sampling (followed by analysis of a wide range of parameters) to determine leachate type and variability throughout the landfill and the relationship to tidal cycles. The longer term surveillance was to include monitoring of water level fluctuations in the boreholes to elucidate water inputs to and outputs from the landfill leading to an understanding of leachate formation and migration, and also periodic sampling and analysis of leachate from the boreholes to see how it is evolving and whether any particularly problematical pollutants can be expected to emerge from the landfill.

2.4 In summary, the investigations would hopefully lead to a fuller understanding of the formation, nature, and movement of leachate and gas within the landfill, which in turn would enable methods of counteracting odour problems to be designed, and to give early warning of the presence of potentially problematical toxic pollutants which could seep into the estuary. Drilling was therefore commenced in May 1984.

III HYDROGEOLOGICAL INVESTIGATIONS

(a) Geological setting

3.a.1 The bedrock of the area is Sherwood Sandstone (Triassic age) which is used as an aquifer in the Belfast area but not in the vicinity of the estuary. The mudflats on which the landfill rests are comprised of 'sleech', a soft, plastic, blue-grey estuarine clay which is a Post-Glacial marine transgression sediment. Layers of sand and silty sand are known to occur within the 'sleech'.

(b) Drilling investigations and results

3.b.1 Thirteen boreholes were drilled by percussion, one per cell, over the site (locations Fig.3). They were all lined and capped to be retained for monitoring as shown in Fig.4. All holes were taken beyond the base of the landfill and three (Nos 2, 7 and 10) were continued deeper to investigate the hydraulic properties of the underlying sediments, to see whether basal leakage from the landfill is likely.

3.b.2 The succession determined is shown diagrammatically in Fig.5. Laboratory measurements of the hydraulic conductivity of U-4 samples of the sleech gave a very low value of 7×10^{-9} cm/sec. The distribution of the sediments is shown by cross-sections (Figs 6 and 7).

3.b.3 The three deep boreholes were backfilled to the base of the landfill, to minimise contamination of the underlying sediments, and all the holes were lined to the landfill base with slotted well screen fitted opposite the basal saturated layer of refuse.

(c) Monitoring

3.c.1 Leachate and refuse samples were collected during and after drilling and monitoring of water levels commenced in August 1984. Installation of autographic water level recorders on the boreholes is a problem because of vandalism so three secure heavy steel huts were acquired to protect recorders. One recorder has been kept continuously on Borehole No1, partly as a control, while the other two recorders/huts have been used to obtain continuous results for several months duration from each of the other holes by moving them periodically. This work is still continuing as not all of the holes have had a recorder installed yet. The recorders are reset weekly and on each visit the water levels in the other boreholes are dipped manually.

3.c.2 The water level records are plotted alongside records from a tidal recorder operated by the Belfast Harbour Commissioners, who kindly provide copies of their charts, and both barometric and rainfall data obtained from the Meteorological Office.

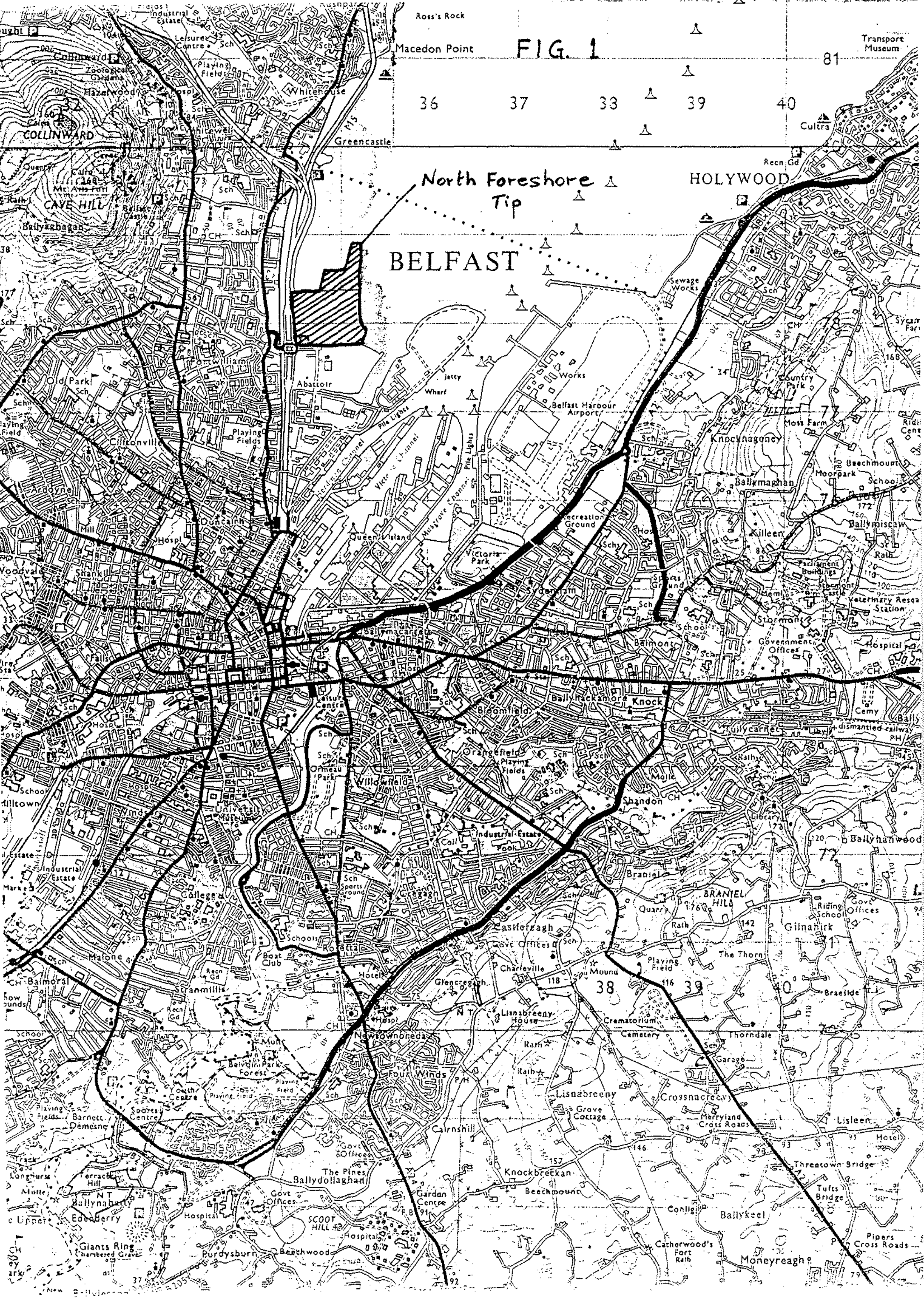
(d) Results and interpretation

3.d.1 The most striking finding from the monitoring is that the tidal effect on the water levels within the landfill is apparently insignificant. On the other hand the levels fluctuate markedly in response to rainfall, and the absence of it. Also the more southerly boreholes which intersect a thicker 'aquifer', the refuse layer , which is confined by a relatively thick partially permeable cover layer exhibit a very well developed response to variations in atmospheric pressure (Fig.8). This barometric effect is a well documented phenomenon in confined natural aquifers: there is an inverse relationship between pressure and water levels, as pressure rises water levels fall and vice versa. The magnitude of the effect depends on both the elasticity of the aquifer and the competence of the confining beds to resist pressure changes. It can be expressed as a barometric efficiency by dividing the observed water level change by the pressure change (expressed as the height of a column of water), giving values of up to 60% at this landfill.

3.d.2 The saturated layer appears to have built up within the landfill, probably mainly by direct infiltration, to a surface which is above the level of high tides, even when the 'aquifer' levels are at their lowest seasonally (Fig.9). Water levels in this 'aquifer' fluctuate seasonally, like a natural one, peaking in winter and falling to a minimum in late summer or early autumn, with individual boreholes displaying maximum variations ranging from 0.34 to 1.01m so far.

3.d.3 The levels and gradients indicate that there is a discharge of leachate from the site throughout the year. To quantify this, values for either specific yield or hydraulic conductivity of the aquifer layer are necessary but they have not been determined at this site. Using a value for hydraulic conductivity of 40 m/day derived in a landfill in England, and a specific yield of 0.15 it is estimated that the discharge may be in the range of 400 m^3/day - 900 m^3/day, but these figures should be treated with great caution.

FIG. 1



North Foreshore Tip
BELFAST
HOLYWOOD
Macedon Point
Greencastle
CAVE HILL
COLLINWARD
Belfast Harbour Airport
Queen's Island
Victoria Park
Sydenham
Ballyhackamore
Knock
Bloomfield
Stormont
Castlereagh
Newtownbreda
Four Winds
Lisnabreeny
Malone
Stranmillis
Ardoyne
Shankill
Falls
Whitehouse
Fortwilliam
Duncairn
Cultra
Transport Museum
Ross's Rock

FIG. 2

Sequence of cell infill to 12 ft level in alphabetical order

(prepared by Cleanaway Ltd)

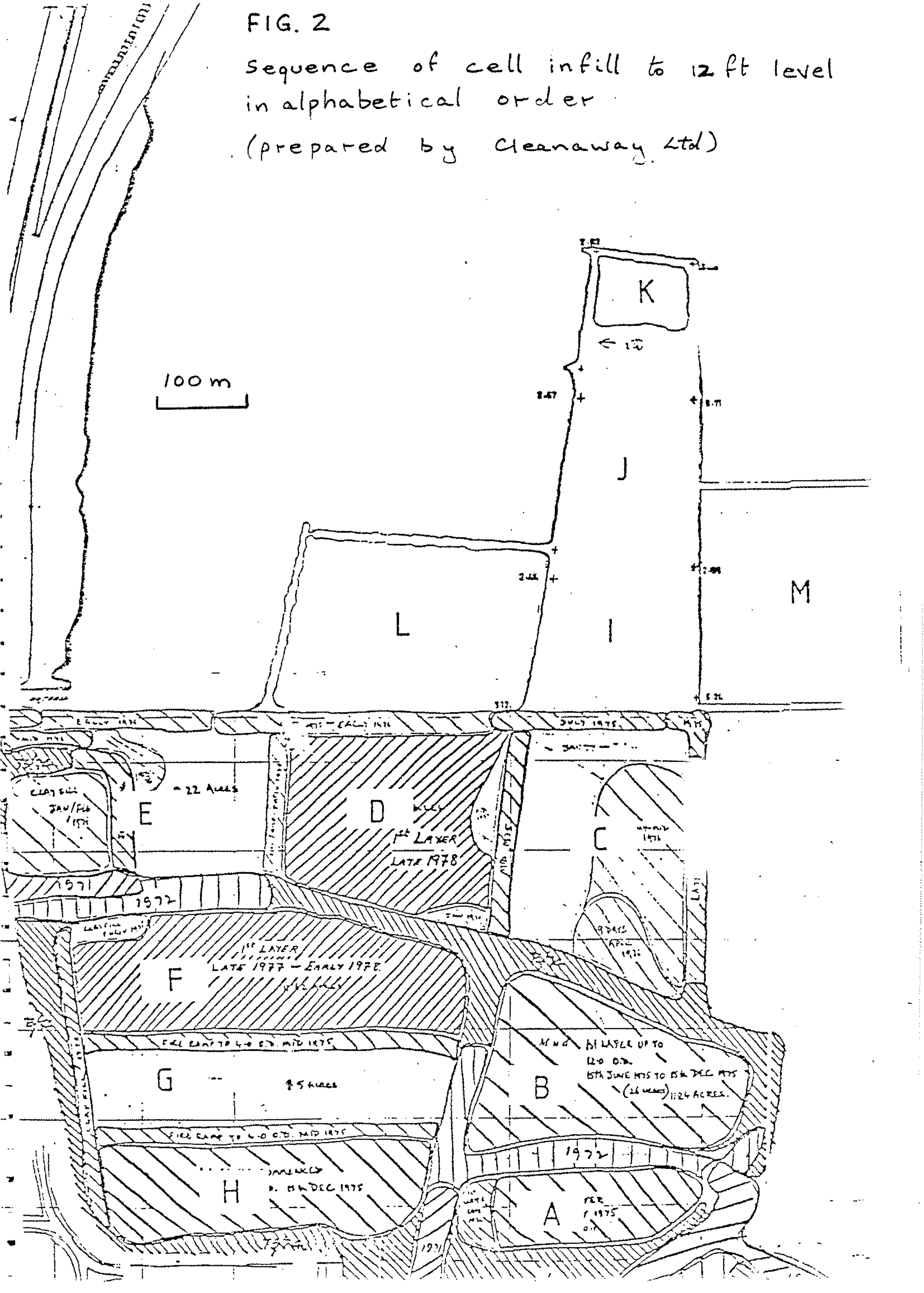


FIG. 3

Borehole locations

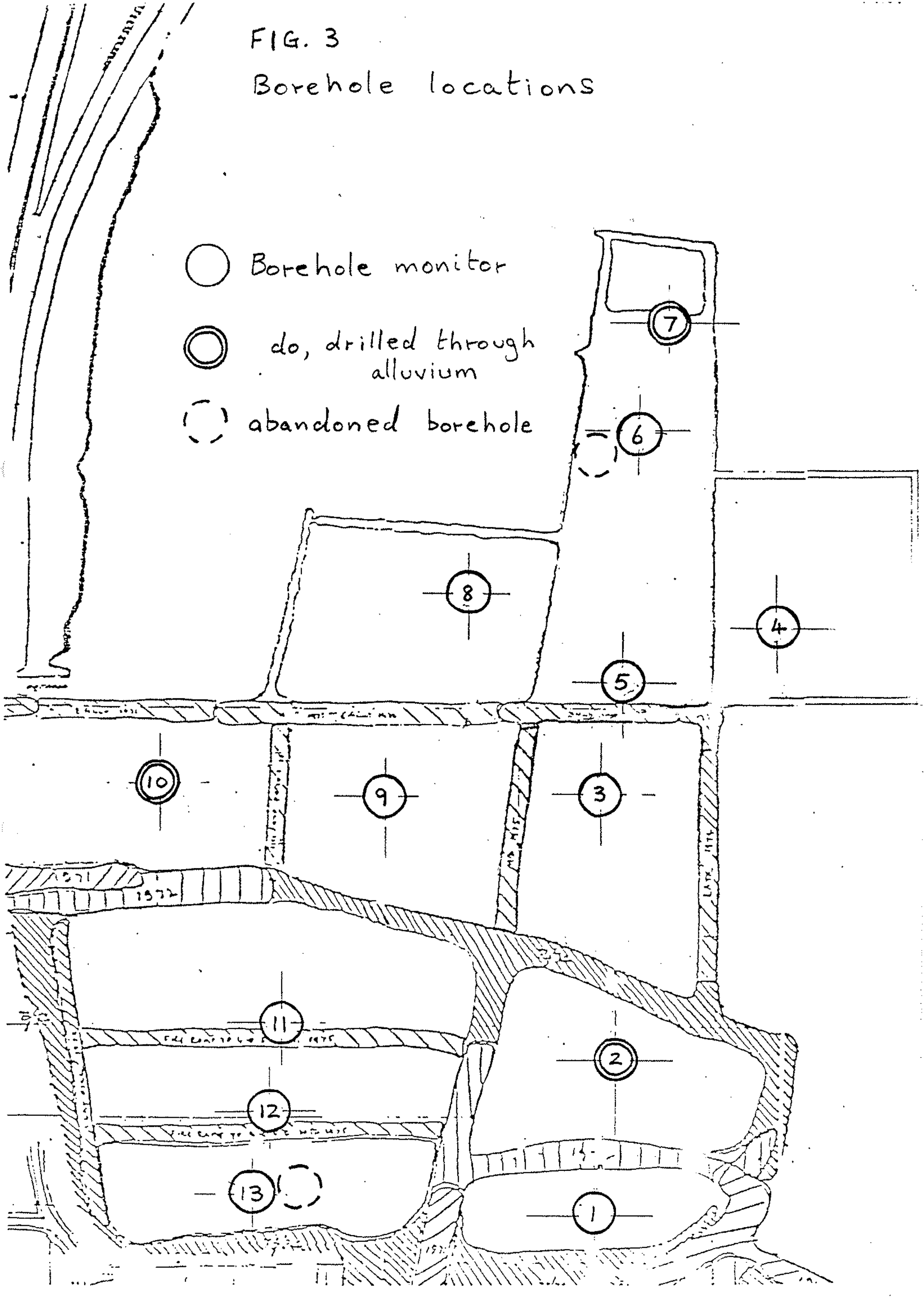


FIG. 4

BELFAST LOUGH NORTH FORESHORE — LEACHATE MONITORS

SCALE 1 : 10

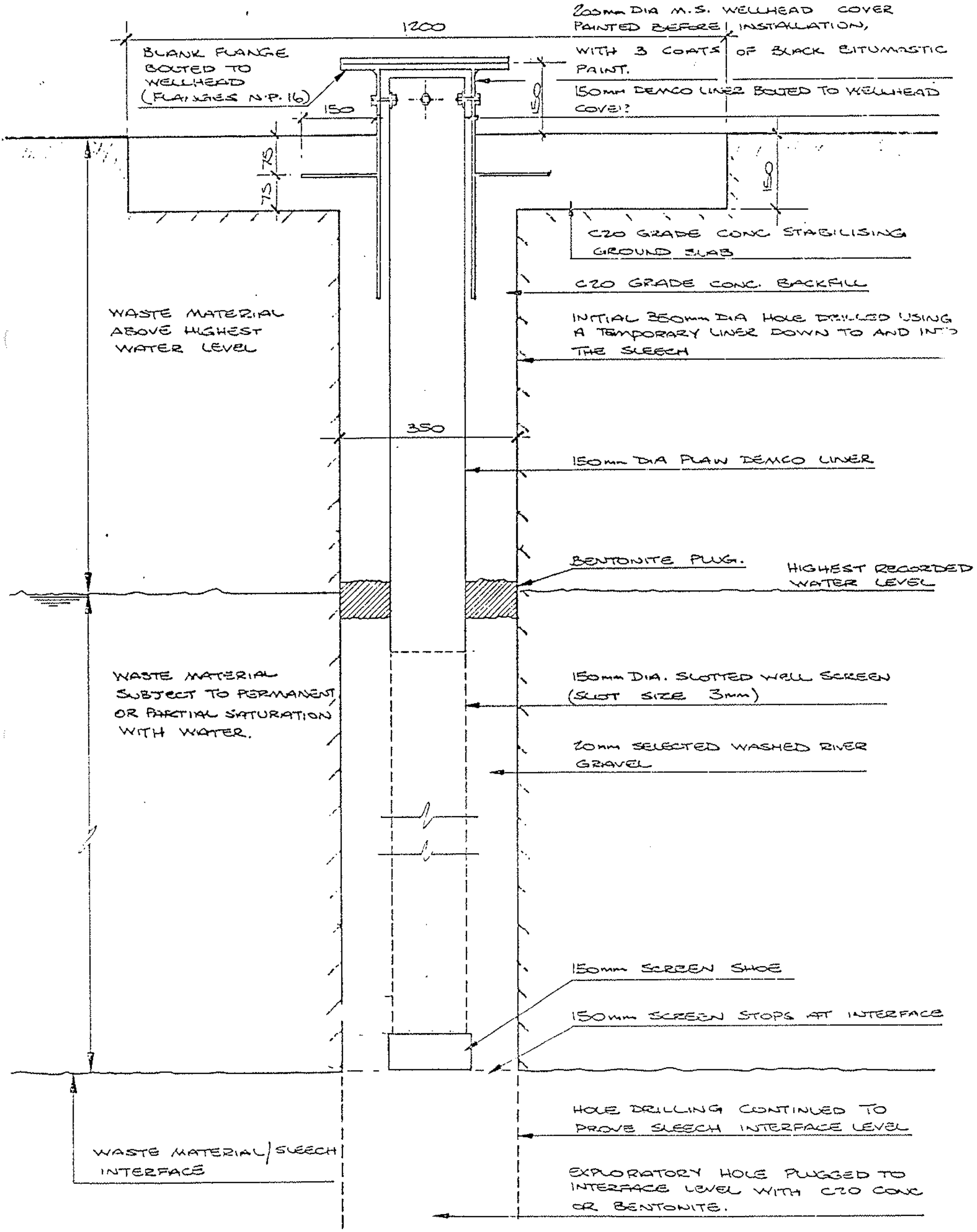


FIG. 5

Geological succession

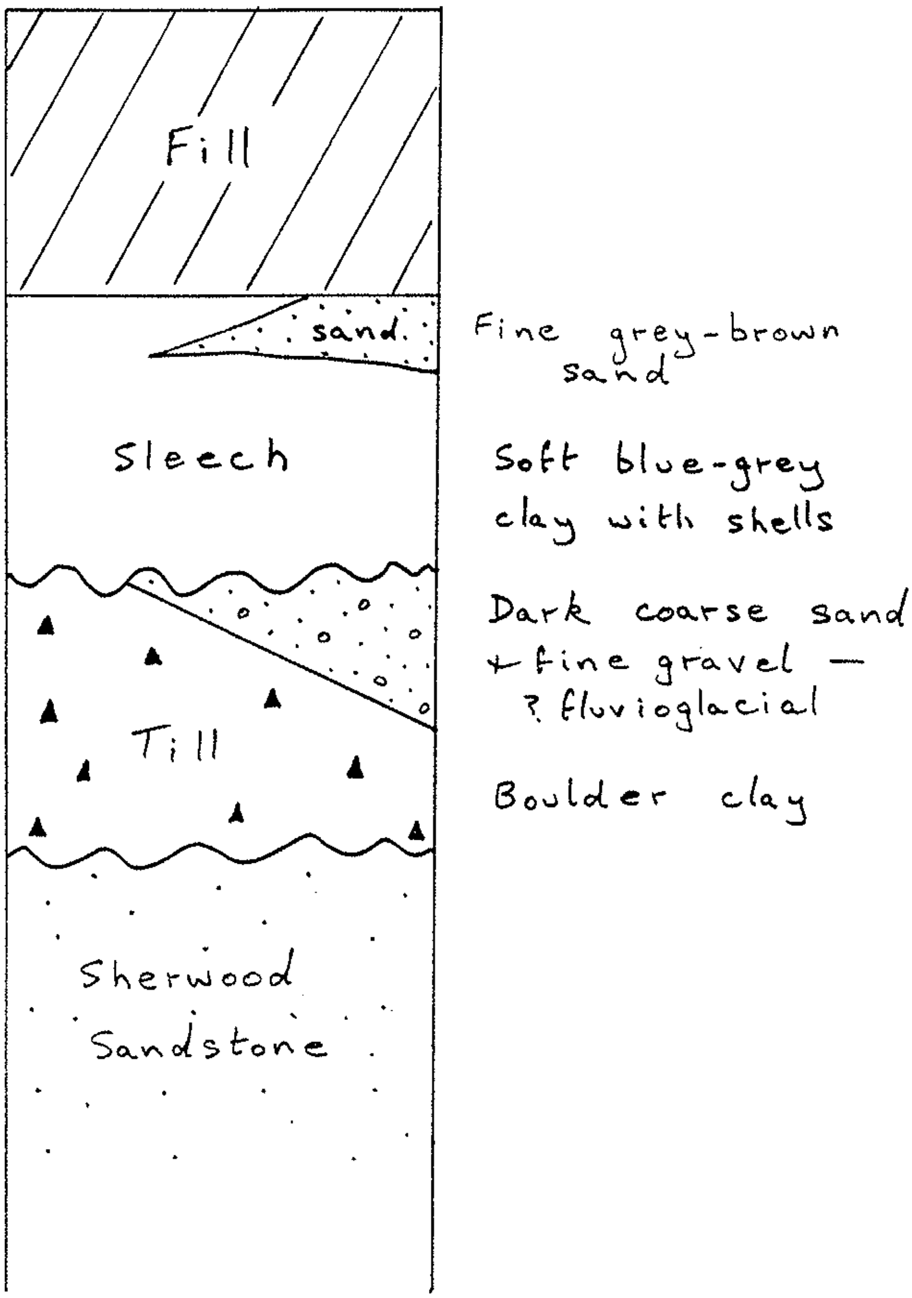


FIG. 6

Lines of section of Fig. 7

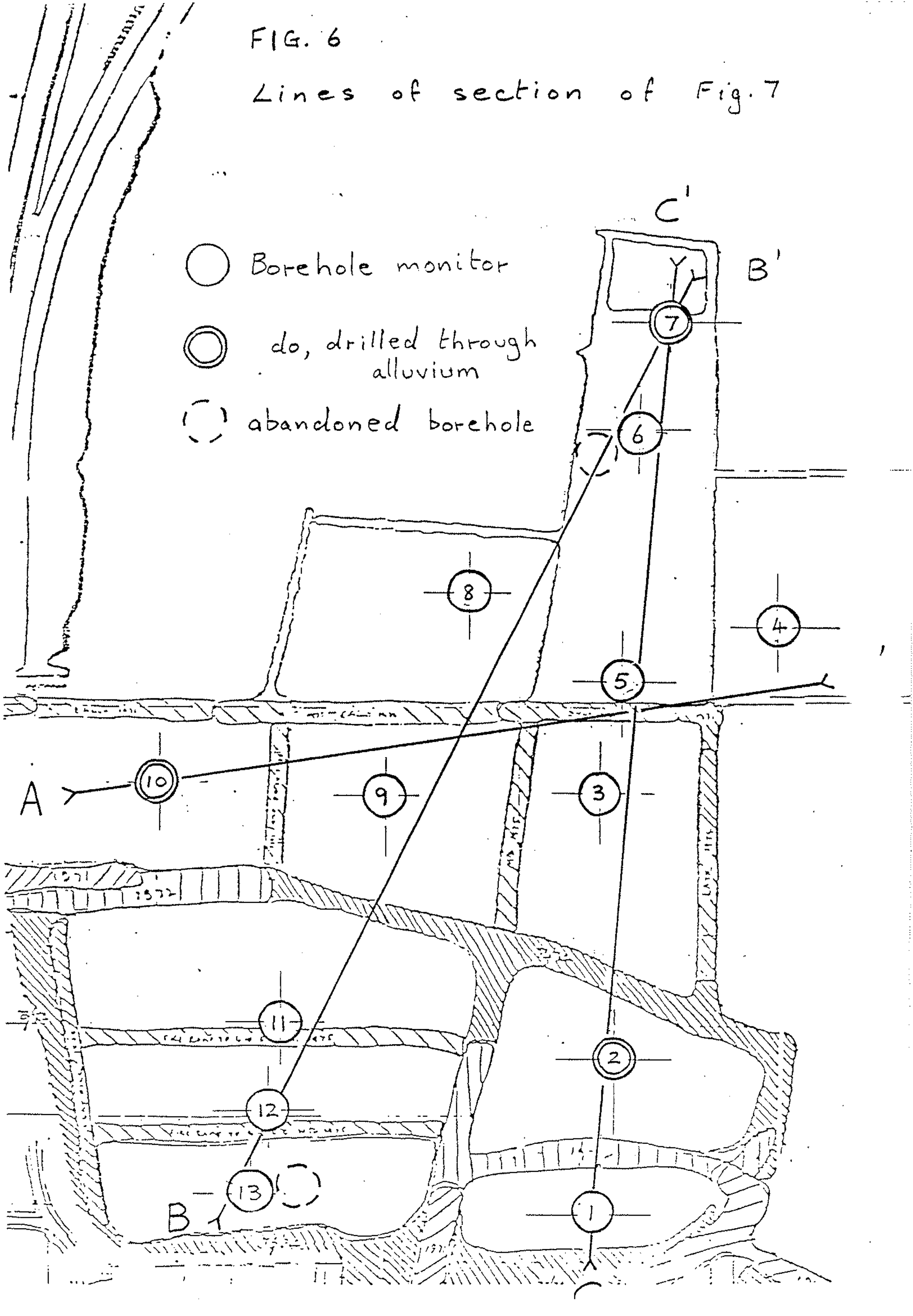


FIG. 7

Cross-sections along lines shown in Fig. 6

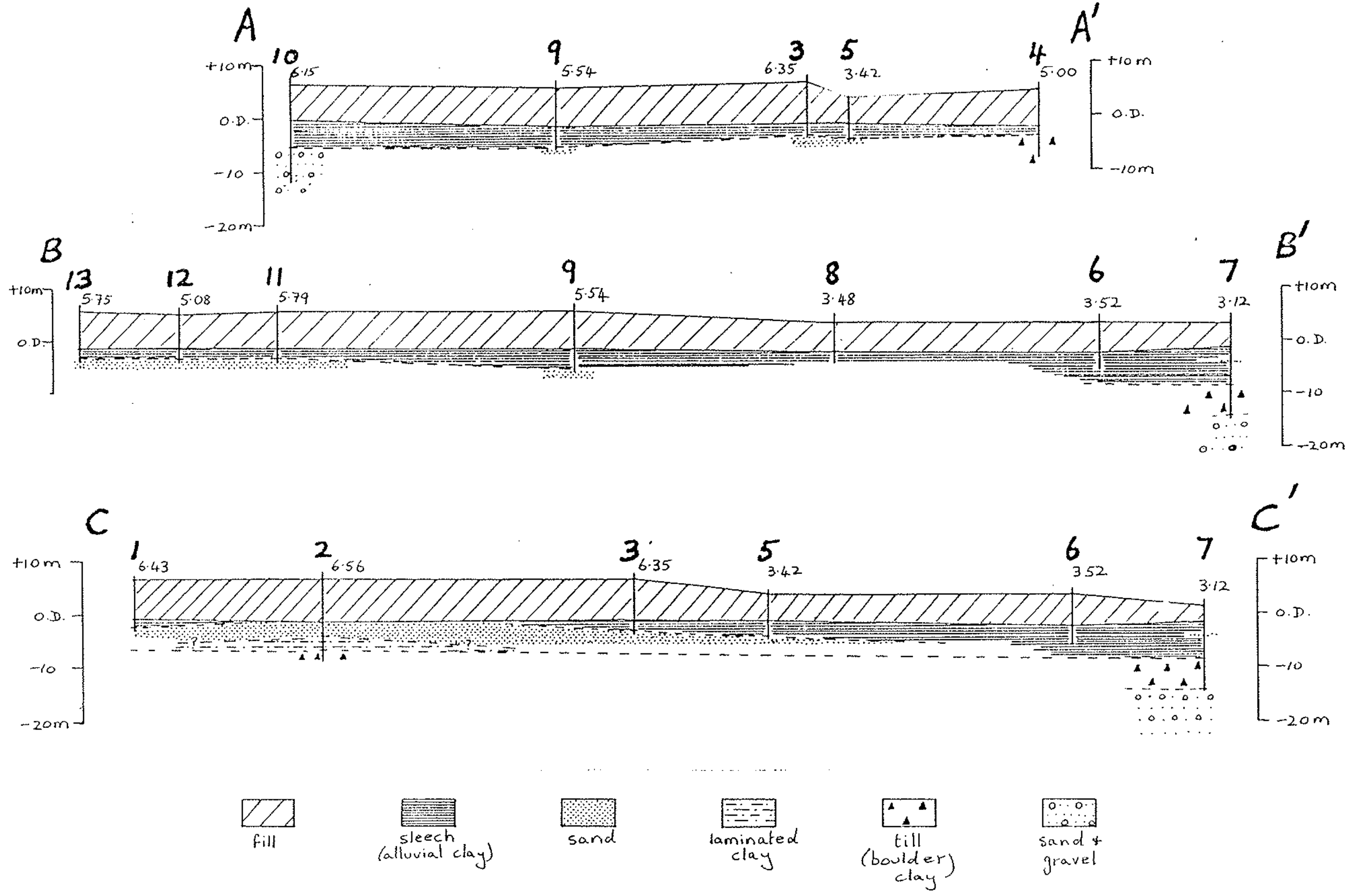


FIG. 8

Borehole water levels

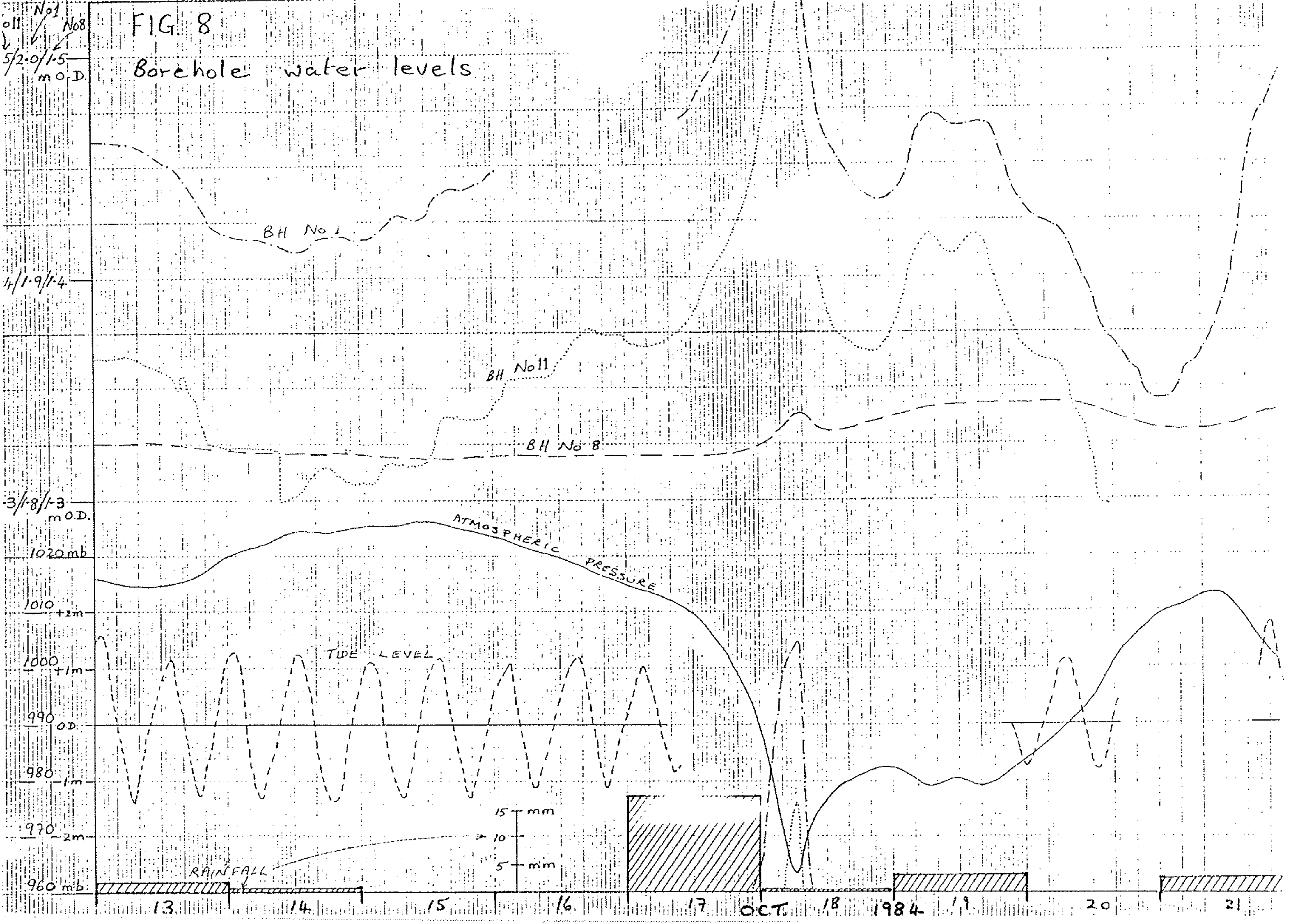


FIG. 9

Minimum water levels, late July - early August 1985