White Young Green

Environmental

Contaminated Land
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Geographic Information Systems
Health & Safety
Hydrogeology
Management Systems
Waste Management

Ewa Babiarczyk,
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26th October 2006.

Dear Ewa,

Thank you for your letter dated 24th October regarding White Young Greens submission regarding the Waste Licence Application for the Fingal Landfill at Nevitt, Lusk, Co. Dublin (Waste Licence Reference Number W0231-01).

Following submission of the report, some amendments have been made based on new data. There are some parts of the text that are now incorrect as a result of the new data. I have enclosed a copy of our revised report and would be very grateful if this revised copy could replace the previous submission made. I am anxious to avoid any confusion regarding the incorrect text in the original report.

I apologise for this mistake and hope it does not cause you any difficulties. If you have any questions or require any other information please do not hesitate to contact me at your convenience (01-2931200).

Yours sincerely,

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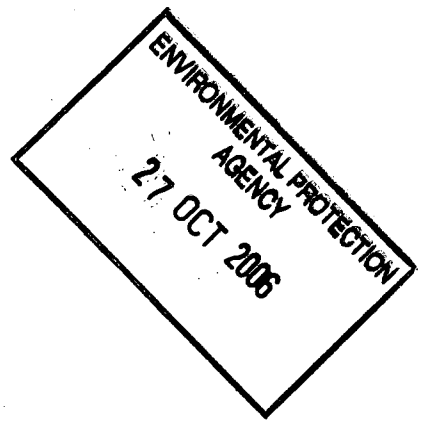
Sub. 42



White Young Green

FINGAL LANDFILL PROJECT
REVIEW OF EIS – SOILS/GEOLOGY/HYDROGEOLOGY

For

Nevitt Lusk Action Group

October 2006

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NEVITT LUSK ACTION GROUP
FINGAL LANDFILL PROJECT
REVIEW OF EIS – SOILS/GEOLOGY/HYDROGEOLOGY

OCTOBER 2006

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1.0 INTRODUCTION

White Young Green Ireland (WYG) were requested by The Nevitt Lusk Action Group to undertake a review of the soils, geology and hydrogeology sections of the Environmental Impact Statement (April 2006) for the Fingal Landfill Project. The objective is to compare the EIS report to recognised standards and to identify any inadequacies that may exist. The Fingal Landfill Project EIS was compiled by RPS Consulting Engineers on behalf of Fingal County Council.

This report deals with Section 3.18 of the EIS – Hydrogeology/Geology and Soils. With regard to geology, soils and hydrogeology, there are a number of documents and guidelines that must be considered in the preparation of an EIS for a landfill facility:

- Environmental Protection Agency, Landfill Design Manual; Investigations for Landfills, 1995
- Environmental Protection Agency, Landfill Manuals; Landfill Site Design, 2000
- Environmental Protection Agency, Advise Notes on Current Practice (in the preparation of Environmental Impact Statements), September 2003
- Environmental Protection Agency, Guidelines on the Information to be contained in Environmental Impact Statements, March 2002
- Institute of Geologists of Ireland, Geology in Environmental Impact Statements A Guide, 2002

The EPA Landfill Design Manual; Investigations for Landfills, 1995 states that "*an investigation aims at determining the nature and behaviour of all aspects of a site and its environs that could be significantly influenced or be influenced by the landfill*". It goes on to say that "*the main objective of an investigation is to ensure an economical and safe development by reducing to an acceptable level of uncertainties and risks that the ground (geology) poses to the project or that the project does to the environment and public health*". The EIS is therefore reviewed in this context.

1.1 EPA Landfill Manuals Guidelines

Chapter 5 of the EPA Investigations for Landfills Manual outlines the requirements of the detailed assessment stage of a landfill investigation. Section 5.3.2 outlines the requirements with respect to soils and bedrock geology and Section 5.3.5 deals with groundwater.

The requirements for soils are given as follows:

- Composition and physical properties of the strata
- Lateral and vertical continuity and distribution of strata
- Resistance to erosion and loss of fines
- Stress and deformation behaviour
- Reusability/workability for earthworks and cover material
- Leachability tests

The geological requirements are specified as follows:

- Type of rock, mineralogical composition and stratigraphy
- Solubility in water and leachate
- Type and position of geological boundaries
- Extent, degree and separation of discontinuities
- Risk of karstification and subsidence
- Deformation behaviour of the rock mass
- Rock permeability (packer tests)
- Soil moisture characteristics
- Contamination

The requirements for groundwater are as follows:

- Groundwater regime
- Permeability of all strata (based on piezometric data)
- Transmissivities of subsoils and bedrock (max and min values)
- Distribution, thickness and depth of subsoils and bedrock
- Location of springs, sink and swallow holes or other groundwater features
- Groundwater gradients, rates of flow, direction of flow
- Groundwater levels and variability
- Groundwater chemistry, natural problems
- Groundwater protection zones
- Groundwater abstraction
- Predicted influence of short/long term dewatering
- Relationship with surface waters
- Groundwater quality
- Groundwater vulnerability and aquifer category

Appendix C of the EPA Landfills Site Design Manual deals with the lining systems that are fundamental to a properly engineered landfill. In particular, Appendix C3 highlights the leakage rates through liners and provides guidance on assessing the volume of leachate likely to leak through various types of liner systems.

1.2 EPA Guidance Documents on EIS

The relevant information from these documents is too lengthy to be reproduced here. However as indicated above the EIS report was reviewed in the context of this these guidelines.

1.3 IGI Guidance on Geology in EIS

The main items of consideration with regard to the soils, geology and groundwater aspects of a landfill investigation are detailed in the IGI document as follows:

Project Type	Significance of Geology	Topics
Project Type 31 Landfills	• Nature of rock/soils - rock stability - need for material capping - deterioration on capping soils due to upward migration of contaminants - transmissivity and hydraulic conductivity of rock • Impacts on groundwater - contamination by uncontrollable surface run-off - contamination of groundwater by leachates - movements of contaminated groundwaters	Soils Water

2.0 REVIEW OF EIS IN CONTEXT OF RELEVANT DOCUMENTS

For ease of reference, each of the 3 topics (soils, geology and hydrogeology) are reviewed separately. Where necessary, text from the EIS document is reproduced.

2.1 Soils

Information on the soils was compiled from two sources:

- desk study based on published information from the Geological Survey of Ireland (GSI) and Teagasc
- Field investigations –geophysical investigation, monitoring well and trial pit installation, pumping tests and subsoil field permeability testing

2.1.1 Gravel Deposits underlying site

Basis of Objection - The presence of gravels directly underlying the proposed landfill has not been adequately addressed by the EIS.

The geophysical survey conducted by BMA Geoservices summarised that a thick sequence of low resistivity boulder clay overlying gravely clay and weathered rock underlying the site. The clay is greater than 24m in the centre of the site. The sequence thins towards the edges of the site so that it is between 5 – 20m thick in these areas. It is less than 5m thick in the southwest and southeast of the site. Outcrop of rock has been mapped in the northwest. The report also highlighted a number of possible geological faults that should be investigated further. This picture is not reproduced in the EIS which states that the landfill footprint area is underlain by a consistent thickness of greater than 10m low permeability material. The outcrop in the northwest of the site is not investigated in the EIS. There does not appear to be any consideration given to the possible geological faults highlighted in the geophysics report.

An examination of the resistivity profiles included in the geophysical report indicates that a large number of these profiles right across the site recorded the presence of gravel at depths ranging from 2-5m to 20-35m. This detail is presented in the table below:

Resistivity Profile	Overburden	Minimum Depth of Gravel (approx.)	Landfill Footprint
2D Res 1	Bld Clay	-	-
2D Res 2	Bld Clay, Sat Grav/Weat Rck	8m	-
2D Res 3	Bld Clay, Sat Grav/Weat Rck	13m	-
2D Res 4	Bld Clay, Sat Grav/Weat Rck	15m	Yes
2D Res 5	Bld Clay, Sat Grav/Weat Rck	6m	-
2D Res 6	Bld Clay, Sat Grav/Weat Rck	5m	Yes
2D Res 7	Bld Clay, Sat Grav/Weat Rck	20m	-
2D Res 8	Bld Clay, Sat Grav/Weat Rck	20m	Yes
2D Res 9	Bld Clay, Sat Grav/Weat Rck	20m	Yes

2D Res 10	Bld Clay, Sat Grav/Weat Rck	15m	-
2D Res 11	Bld Clay, Sat Grav/Weat Rck	10m	-
2D Res 12	Bld Clay	-	-
2D Res 13	Bld Clay	-	-
2D Res 14	Bld Clay	-	-
2D Res 15	Bld Clay, Sat Grav/Weat Rck	5m	-
2D Res 16	Bld Clay	-	-
2D Res 17	Bld Clay, Sat Grav/Weat Rck	17m	-
2D Res 18	Bld Clay, Sat Grav/Weat Rck	15m	Yes
2D Res 19	Bld Clay	-	Yes
2D Res 20	Bld Clay, Sat Grav/Weat Rck	7m	-
2D Res 21	Bld Clay	-	-
2D Res 22	Bld Clay, Sat Grav/Weat Rck	2m	-
2D Res 1 L	Bld Clay, Sat Grav/Weat Rck	3m	-
2D Res 2 L	Bld Clay, Sat Grav/Weat Rck	10m	-
2D Res 3 L	Bld Clay, Sat Grav/Weat Rck	22m	Yes
2D Res 4 L	Bld Clay, Sat Grav/Weat Rck	27m	Yes
2D Res 5 L	Bld Clay, Sat Grav/Weat Rck	5m	Yes
2D Res 6 L	Bld Clay, Sat Grav/Weat Rck	12m	Yes
2D Res 7 L	Bld Clay, Sat Grav/Weat Rck	32m	Yes
2D Res 8 L	Bld Clay, Sat Grav/Weat Rck	30m	-
2D Res 9 L	Bld Clay, Sat Grav/Weat Rck	6m	Yes
2D Res 10 L	Bld Clay, Sat Grav/Weat Rck	10m	Yes
2D Res 11 L	Bld Clay, Sat Grav/Weat Rck	20m	Yes
2D Res 12 L	Bld Clay, Sat Grav/Weat Rck	22m	Yes
2D Res 13 L	Bld Clay, Grav Clay/Weat Rck	-	-
2D Res 14 L	Bld Clay, Sat Grav/Weat Rck	45m	-
2D Res 15 L	Bld Clay, Sat Grav/Weat Rck	20m	-
2D Res 16 L	Bld Clay, Sat Grav/Weat Rck	22m	Yes
2D Res 17 L	Bld Clay, Sat Grav/Weat Rck	3m	-
2D Res 18 L	Bld Clay, Sat Grav/Weat Rck	8m	Yes
2D Res 19 L	Bld Clay, Sat Grav/Weat Rck	35m	Yes
2D Res 20 L	Bld Clay, Sat Grav/Weat Rck	10m	Yes
2D Res 21 L	Bld Clay, Sat Grav/Weat Rck	21m	-
2D Res 22 L	Bld Clay, Sat Grav/Weat Rck	15m	-
2D Res 23 L	Bld Clay, Sat Grav/Weat Rck	35m	-
2D Res 1A EIS	Bld Clay, Sat Grav/Weat Rck	7m	-
2D Res 1B EIS	Bld Clay, Sat Grav/Weat Rck	20m	Yes
2D Res 2A EIS	Bld Clay, Sat Grav/Weat Rck	10m	Yes
2D Res 2B EIS	Bld Clay, Sat Grav/Weat Rck	18m	Yes
2D Res 3A EIS	Bld Clay, Sat Grav/Weat Rck	15m	Yes
2D Res 3B EIS	Bld Clay, Sat Grav/Weat Rck	8m	-
2D Res 4 EIS	Bld Clay, Sat Grav/Weat Rck	22m	Yes
2D Res 5 EIS	Bld Clay, Sat Grav/Weat Rck	10m	Yes
2D Res 5B EIS	Bld Clay, Sat Grav/Weat Rck	4m	-
2D Res 6 EIS	Bld Clay, Sat Grav/Weat Rck	8m	Yes

Abbreviations:
Bld Clay – Boulder Clay
Sat Grav – Saturated Gravel
Weat Rck – Weathered Rock
Grav Clay – Gravelly Clay

While some appear to be isolated gravels, the geophysical profiles show areas in the centre of the site that appear to be underlain by continuous gravel deposits. The EIS acknowledges the presence of 'some sand and gravel deposits' that 'vary across the study area with thicknesses ranging from absent

to 10m'. However, the EIS fails to adequately discuss or further investigate the gravels identified directly beneath the landfill footprint by the geophysical survey. The drilling work carried out subsequent to the geophysics should have specifically targeted the areas identified as being underlain by gravel. If this was carried out, it would be possible to produce a detailed contour map of the subsurface particularly showing the areas where gravel is present less than 10m below the surface.

The GSI Source Protection Zones Report for the Bog of the Ring public water supply states that the production wells are maintained by a high transmissivity zone which is supported by a significant gravel horizon. The connection between the gravels underlying the proposed landfill site and the gravels associated with the Bog of the Ring public supply have not been adequately investigated by the EIS. It is therefore unknown if a link does exist and what implications this may have for the integrity of the public supply which abstracts in the region of 4 ML/d.

The presence of gravels within the area has implications for the vulnerability rating. The vulnerability of an aquifer describes the ease at which it may become contaminated. The EIS indicates that the vulnerability is Low (L), based on an excess of 10m of low permeability clay. The presence of high permeability gravel will increase the vulnerability, to either Extreme (E) or High (H) depending on the exact thickness, which in turn will have consequences for the groundwater protection response associated with a proposed landfill development. The EIS is lacking a detailed site specific vulnerability map. Given the detailed geophysical data and numerous borehole logs along with the potential impacts from such a development on groundwater this is considered a major oversight that must be addressed. The GSI methodology for classifying vulnerability is presented in the Table below.

Vulnerability Rating	Hydrogeological Requirements (below the point of release of contaminants)				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Recharge Type
	high permeability (sand/gravel)	moderate permeability (sandy till)	low permeability (clayey till, clay, peat)	(sand & gravel aquifers only)	
Extreme	0-3.0m	0-3.0 m	0-3.0m	0-3.0m	point (<30 m radius)
High	>3.0	3.0-10.0m	3.0-5.0m	>3.0m	N/A
Moderate	N/A	>10m	5.0-10.0m	N/A	N/A
Low	N/A	N/A	>10.0m	N/A	N/A

Notes: i)N/A =not applicable
ii) Precise permeability values cannot be given at present
iii) Release point of contaminants is assumed to be 1-2 m below ground surface

(from Daly & Warren 1997)

The GSI Quaternary Section and Public Office were contacted and visited in order to view maps detailing the Quaternary geology of the area. The original 6" field sheet (1:10,560) compiled during the 19th century shows a deposit of gravel at Pamelstown, about 1km to the west of the proposed landfill

footprint. The sheet corresponding to the area of the proposed landfill had very poor quality handwriting and so it was not possible to determine if gravel was mapped in this area during the original 19th century survey. A map of the Quaternary Geology of the area dated April 2006 shows deposits of gravel mapped to the north and south of the proposed landfill at Rowans Little and Wimbletown Bridge respectively.

The presence of gravel in the area has been documented through several sources, including the geophysical investigations undertaken for the EIS. Given this volume of data it is considered an oversight that the EIS did not investigate and clarify the extent, depth, origin or aquifer properties of this gravel.

2.1.2 Depth to Bedrock

Basis of Objection – Lack of clarity on the number of boreholes investigating the subsurface below the proposed landfill footprint

The EIS summarises the clay overburden deposits as 'varying in thickness from 3.1m to 29.7m. The landfill footprint is sited where the clay is 20m to 25m thick'. The clay is reported to have two distinct layers – an upper firm light brown sandy gravely clay approximately 2.5m thick and then a stiff to very stiff grey to black sandy gravely clay with occasional cobbles and boulders. This thickness of clay material results in the site having a Low (L) vulnerability rating (as per the GSI vulnerability mapping guidelines) which is good in terms of groundwater protection. The EIS states that a minimum of 10m of low permeability clay will be maintained beneath the landfill footprint as per EPA guidelines and requirements.

Figure 3.18.6 in the EIS displays the locations of the various monitoring wells drilled at the site. The figure does not outline the landfill footprint and it is therefore not clear how many of these monitoring wells investigate the surface directly below the proposed landfill area. From studying the EIS and the accompanying maps it appears that some 15 monitoring wells were installed into the clay layer and 4 into the gravel layer underneath the landfill footprint. The data and its interpretation would be more transparent produced listing all boreholes and trial pits with their final depths and details on the formations encountered. The current lack of transparency with regard to the number of boreholes within the landfill footprint means that it is difficult to make an informed decision on whether sufficient data has been presented. Similarly a contour plot of the depth to bedrock directly beneath the proposed landfill would be extremely useful in assessing the suitability of this site. The depth to bedrock data should be used to compile a site specific vulnerability map for the area.

2.1.3 Borehole Details

Basis of Objection – Lack of explanation of borehole details

The specialist Soils report in Volume 5 Appendix I of the EIS goes into more detail about the investigations undertaken.

The number of boreholes and the materials they encountered are described here. On Page 10 of this report, mention is given to an 'anomaly encountered in AGB4 where sandy GRAVEL to a depth of 4.5m was encountered'. This is followed by 'a secondary borehole, ASA3, was constructed adjacent to AGB4 and encountered CLAY to a depth of 19m'. The report gives no explanation of this anomaly nor describes any further investigations that were undertaken to account for this.

2.1.4 Increase in suspended solids load

Basis of Objection – Lack of explanation of mitigation measures proposed for suspended solids load

While the EIS is detailed in its analysis of the engineering and construction aspects of the soil (Section 5 of Soils report) consideration does not appear to have been given to the resistance to erosion and loss of fines. It is inevitable that the excavation and construction will lead to an increase in the suspended solids load entering watercourses as indicated in the Impacts section of the report. The remedial or reductive measures section indicates that 'attenuation measures will be implemented to protect watercourses from soil particles mobilised as suspended solids'. It is not clear what these attenuation measures will consist of and no details of the sizing or design of attenuation ponds is given. WYG would contend that a detailed picture of such attenuation measures is critical to the protection of watercourses. In particular the anticipated increase in suspended solid load should be quantified and a suitable design for an attenuation pond or other mitigation measures presented.

2.1.5 Permeability of Subsoil

Basis of Objection – Absence of sufficient information on permeability of subsoil for mineral liner

Table 6 in Appendix H presents a summary of the average permeability values of the subsoils as derived from packer tests. The permeability values vary from $1.5x10^{-5}$m/s to $4.5x10^{-7}$ms. The EPA Landfill Site Design Manual specifies that the hydraulic conductivity of the mineral lining layer is 10^{-9}m/s. It is not clear from reading the EIS if lower permeability material will be imported onto the site or if the existing material will be compacted. Such information is required in order to assess the suitability of the site for a landfill facility.

2.2 Geology

Basis of Objection – Lack of clarity on the bedrock formations directly underlying the site

The EIS presents the published geological information for the area in great lengths i.e. that the area is underlain by a series of Carboniferous aged limestones, mudstones and shales. The data indicates that 3 bedrock formations underlie the site, but site specific data would be required to clarify the position and nature of these boundaries. A large number of boreholes were drilled around the landholding but it is difficult to assess how many of these are within the landfill footprint itself as this area is not displayed on the relevant maps. The data from these boreholes does not appear to have been used to clarify the locations of the lithological boundaries on the site. A site bedrock map based on the findings of the boreholes would be extremely useful in establishing the bedrock conditions underlying the landfill footprint.

The bedrock types are classified by the GSI as different aquifer bodies with different groundwater potentials. WYG therefore believe that a clear understanding of the locations of the bedrock types and the boundaries between them is highly important in understanding how the proposed landfill would interact with the subsurface. The lack of clarity on the bedrock directly beneath the site has implications for the hydrogeological conceptual model (this is discussed further below in Section 2.3).

The contact between the various geological formations is often known to facilitate groundwater movement. Therefore these areas often have higher groundwater potential than the surrounding more competent bedrock. It is therefore clear that these zones should be clearly identified and understood.

2.3 Hydrogeology

Various aspects of the hydrogeology section of the EIS which are considered to be inadequate are discussed in this section.

2.3.1 Proposed Location on Only Productive Aquifer in Region

Basis of Objection – The proposed location of the landfill on the only productive bedrock aquifer within Co. Dublin

The recent EPA publication on the Water Quality in Ireland 2005 highlights the fractured limestone bedrock in north Co., Dublin as being the only productive bedrock aquifer in the county. The aquifer is known to extend from the coast of north Dublin to Dunshaughlin in Co. Meath. The Loughshinny Formation is the most productive part of this aquifer and directly underlies the northern portion of the proposed landfill footprint. The Bog of the Ring Public Water Supply Scheme is abstracting in the region of 4Ml/d of groundwater from this aquifer. This scheme currently supplies the populations of

Naul, Skerries and Balbriggan with water – in the region of 20,000 people.The Dunshaughlin Public Water Supply is currently being developed by Meath County Council. This scheme involves the abstraction of 7800m³/d of groundwater for the Dunshaughlin area from the Loughshinny Formation – the same bedrock aquifer underlying the proposed site for the Fingal Landfill. The aquifer is currently supplying the water needs of many large scale food growers in the north Dublin area. The EIS failed to mention the reliance on this aquifer for public water supply.

2.3.2 Impact on Downgradient Wells

Basis of Objection - The direction of groundwater movement has been identified in the EIS but the potential risk to abstraction wells that are located downgradient of the site has not been investigated.

The Hydrogeology report contained in the Technical Appendices section of the EIS details the well survey undertaken in the area. The text is detailed in Section 3.4.6.3 and further details in Appendix A8 of Technical Appendix H. In addition to these sections, Figure 3.18.5 in the main text displays the bedrock groundwater contours based on data collected in October 2005.

The groundwater contour map shows a groundwater divide located a short distance to the north of the landfill footprint. Immediately to the east of landfill footprint the groundwater movement is shown occurring from north to south. Groundwater is shown to be moving towards this north – south low both from the eastern side and also from the western side. To the east of the north – south movement trend, groundwater appears to be moving from east to west or northeast – south west. On the western side of the north – south movement trend groundwater is moving beneath the landfill footprint from northwest to southeast. The conclusion from the map is that the ultimate direction of groundwater movement is from the north towards the south in the region of the landfill footprint.

Section 3.4.4 of the report identifies a well used by Kerrigans Market Garden Company but suggests that this well is not downgradient of the landfill. An unnamed Figure in Appendix H entitled 'Location of Private Wells' displays Kerrigans Well (denoted P1 on the map) located some 750m directly south of the landfill footprint. This directly contradicts the groundwater contour map (Figure 3.18.5) as described above. If groundwater is ultimately moving from the landfill in a southerly direction, as suggested by the EIS itself, and if Kerrigans well is located due south of the landfill, then it is downgradient. The zone of contribution to a well extends away from it in an upgradient direction. Although the zone of contribution to Kerrigans wells has not been delineated, it can be assumed that it will extend upgradient i.e. towards the proposed landfill site. It is therefore possible that the zone of contribution to Kerrigans well may extend beneath the proposed landfill footprint. A landfill development within the protection zone of a water supply well is not permitted except in an outer protection area with Low (L) vulnerability where the response states such a development would not generally be acceptable unless a series of conditions can be met.

The inadequacies in the well survey procedures may mean that some wells have not been identified or recorded. The same unnamed Figure also shows 3 other wells that are located in a downgradient direction from the landfill footprint. The risk to these wells does not appear to have been considered in the EIS.

2.3.3 Bog of the Ring Public Supply

Basis of Objection – Impact on Bog of the Ring Public Supply not adequately assessed

The EIS does include a review of the Bog of the Ring groundwater resource that supplies in the region of 4000m³/d to the populations of Naul, Skerries and Balbriggan. The wells supplying this public scheme are abstracting from the Loughshinny Formation which also underlies the proposed landfill footprint. The GSI have delineated the zone of contribution to the Bog of the Ring well field and the boundary of this zone is in the region of 250m away from the proposed landfill footprint. The EIS includes some details on how this zone of contribution is likely to extend should the abstraction scheme be expanded in the future. As the future scenarios discussed in the report have not yet been implemented the predictions on the changes in the zone of contribution are purely theoretical. With the ever expanding populations of Dublin and its surrounding counties, groundwater resources are under increasing pressure to meet demands. The EIS states that a review of the sustainable yield of the Bog of the Ring well field is currently being undertaken on behalf of Fingal County Council. It is possible that this work may result in a revision of the zone of contribution to the well field. WYG suggest that this report is fundamental in confirming the importance of the aquifer resource and must be fully considered in assessing the likelihood of impacting this resource.

The aquifer is classified by the GSI as a Locally Important Aquifer that is generally moderately productive (Lm). The GSI Groundwater Protection Responses for Landfills specifies the following responses under the following conditions:

- Where the aquifer classification is Lm and the vulnerability is Low (resource protection code Lm/L), the groundwater protection response is: R1: Acceptable subject to guidance in the EPA Landfill Design Manual or conditions of a waste licence
- Where site is classified as the outer protection zone (SO) of a source protection area and the vulnerability is Low (source protection code SO/L), the groundwater protection response is R3[1]: Not generally acceptable, unless it can be shown that i) the groundwater in the aquifer is confined; or ii) there will be no significant impact on the groundwater; and iii) it is not practicable to find a site in a lower risk area.

This clearly demonstrates the serious implications that may arise should the zone of contribution to the Bog of the Ring scheme be increased to incorporate the landfill site.

2.3.4 *Well Usage in the Area and Aquifer Classification*

Basis of Objection – Well Survey inadequate and insufficient investigation into the importance of this aquifer for the agricultural and horticultural industries

This part of Co. Dublin has a long history of agricultural and horticultural production. Both forms of production have a heavy reliance on high quality water for plant growth and livestock needs. In light of the significance of the groundwater resource in the area, a thorough well survey of domestic and farm properties would be required in order to sufficiently assess the potential impact that compromising the groundwater resource would. The well survey undertaken in the EIS is not considered satisfactory. After initial investigations into the water supplies in the area, WYG established that there are numerous wells, some very high yielding, that were not identified in the EIS.

In general, the following strategy should be employed when carrying out a well survey associated with this type of proposed development. A suitable radius around the site, based on a number of factors including vulnerability rating, would be examined and all wells within this zone recorded. The final product of such a survey should include a map showing the locations of all properties within the selected zone. This map should be accompanied by a table detailing the water supply status at each of these properties i.e. mains supply with no well, well used for horticultural with mains for domestic use etc etc. Where a well is identified on a property, efforts must be made in conjunction with the owner to catalogue the current status of the well. The following should be the minimum details recorded; well type, use, depth, diameter, construction details, current quality, abstraction volumes and pumping regime. Where possible, historical details on the well performance should be noted.

Based on the reasons outlined above the well survey conducted as part of the EIS was not sufficient. WYG carried out an assessment of the volumes of groundwater being abstracted from the aquifer underlying the site. Two sources of data were compiled and examined. Neither of these data sources was included in the EIS. These sources of data are as follows:

- Dunnes Well Drilling Services, a local well drilling company, provided records of the wells they have drilled in the area in recent years.
- WYG carried out a door to door well survey to identify any additional wells not accounted for by the Dunnes records (locations shown in Figure 1 attached)

Dunnes provided information on the wells drilled in the areas around Ballyboughil, Lusk and Rush. The records indicate that these wells are abstracting significant volumes of groundwater as follows:

Area	No. of Wells recorded by Dunnes	Volume abstracted m³/d
Ballyboughil	10	4,912
Lusk	13	7,671
Rush	33	4,812
Combined Total (m³/d)		17,395

The well survey conducted by WYG aimed to identify any wells in the area that had not been accounted for in the information provided by Dunnes. The well survey was carried out over 1 day so it is possible that other wells, not identified in the survey, exist also. This survey focussed on the large groundwater users in the catchment, namely the market gardens and horticulture industry. Ten wells were identified as follows:

Well I.D (Figure 1)	User Name	Abstraction Rate (m^3/d)	Aquifer	Comment
A	Thomas Moore	654	Bedrock	Vegetable processing plant
B	Tim Bergin	2725	Bedrock	Irrigation and domestic use for up to 10 farmers
C	Paddy Keogh	1635	Gravel	Packing, washing
D	John Roggers	436	Bedrock	
E	Thomas Kerrigan	1962	Bedrock	Vegetable processing plant
F	John Thorn	872	Bedrock	Spraying
G	Country Crest	3216	Bedrock	Food processing
H	John Murray	872	Bedrock	Cucumber grower
I	John Landy	436	Gravels	Tomato and lettuce grower

This preliminary assessment indicates that some $10737m^3/d$ and some $2071m^3/d$ of groundwater is available for abstraction from the bedrock and gravel respectively fro the wells that are present. When combined with the figures provided by Dunnes, it indicates that at least $30,203m^3/d$ is available for abstraction from the aquifer in the region of the proposed landfill site. These figures only accounts for wells that are currently present, it does not account for any potential future developments.

2.3.5 Future Use of Groundwater Resource

Basis of Objection – The EIS fails to establish the risk to the future use of this aquifer

Although the Bog of the Ring well field is mentioned in the EIS, sufficient consideration is not given to the groundwater potential of the aquifer in the region of the site. This aquifer is highly productive and supplies the water needs of a number of growing population centres. The EIS does not establish the nature of the subsurface between the landfill and the highly productive Bog of the Ring well field. The hydraulic connection between these two parts of the aquifer has therefore not been established sufficiently to be satisfied that there is no risk. The presence of a landfill site on such an important aquifer has the potential to limit the future use of this aquifer. Dublin and its surrounding areas are

coming under increasing pressure as the mains water network is falling behind the rapid increases in development. An increased reliance on groundwater is a natural consequence of this.

The Draft Feasibility Study of the Greater Dublin Water Supply – Major Source Development Report (May 2006) produced by RPS Consulting Engineers states '*as in the past, the Greater Dublin Area is again approaching the stage where new long-term supplies of water are critical to the next phase of its development, so that it can continue to grow and contribute to the optimal performance of the state as a whole – economically, socially and environmentally – as envisaged in the National Spatial Strategy for balanced development which is a key component of the overall National Development Plan'*. The report goes on to discuss the growing demand on water resources which will lead to water shortages and it highlights that '*New supplies, therefore, are an essential part of the GDA strategy for long term water supply*'.

It is clearly understood that the available water resources for the Greater Dublin Area are stretched. While standard practice for EIS is to state that the developer will replace any water supplies affected by the proposed development, such mitigation is not considered feasible in this instance for a number of reasons:

- The Bog of the Ring Public Supply Scheme abstracts in the region of 4ML/D. This scheme is currently abstracting close to its maximum output (currently under investigation for Fingal County Council). Therefore, WYG contend that it would be unfeasible to replace this output with either surface or groundwater sourced elsewhere in this catchment.
- The numerous high yielding wells used in the horticultural and food production industries are integral to the sustainability of this industry
- The National Standards Authority of Ireland (NSAI) monitor the quality of water used to wash and process the food products grown in this area. In particular, there are strict controls in place regarding the levels of chlorine used. Therefore it would not be feasible to replace these wells with a mains supply due to the chlorine levels associated with mains water.

The future of individual businesses, the food production industry in the area and domestic groundwater users is reliant on the continued use of the high quality, high yielding groundwater resource in the area.

2.3.6 Groundwater Discharges

Basis of Objection – Lack of detailed assessment of groundwater discharges in catchment

The EIS reproduces text from the Eastern River Basin District Summary of Initial Characterisation Report on groundwater discharges. This text consists of general information on this region and background information on the typical groundwater discharge methods i.e. baseflow to surface water, abstraction through wells or springs. The movement of groundwater through this aquifer has been

considered by the EIS in a general manner however a detailed conceptual model for the aquifer has not been presented. The groundwater section of the EIS does not quantify the volume of groundwater moving through or discharging from the aquifer system. The report states that 'groundwater discharges from the Lusk-Groundwater Body via baseflow to streams; as springs and at abstractions via wells, notably the Bog of the Ring Public Water Supply. The main discharges are to the north and southeast'. Should contamination of the aquifer occur then these discharges may also be impacted on. It would therefore be useful to have a clear understanding of these discharges including information on the type of discharge, the quantity of the discharge and the travel time between the potential source of contamination (i.e. the landfill) and the receptor (i.e. the groundwater discharge point).

Section 3.18.6.2 of the main report (Risk Assessment) states that 'nearby surface watercourses are not considered to be receptors due to their lack of connectivity with groundwater in the bedrock aquifer beneath the site'. This risk assessment section fails to consider the hydraulic connectivity between the surface water courses and the shallow groundwater in the overburden layers. This shallow water would be impacted on before the deeper groundwater in the event of contamination leaking from the base of the landfill. If this shallow water is providing base flow to surface watercourses then an obvious risk exists.

2.3.7 Aquifer Characteristics and Impact of Leakage – Risk Assessment

Basis of Objection – No quantitative risk assessment or calculation of travel times

Appendix C3 of the EPA Landfill Site Design Manual includes details on quantifying the volume of leachate that may potentially leak from a landfill through various thicknesses of mineral liner. The seepage rate is determined by the thickness of the liner, head of leachate above the liner and the hydraulic conductivity of the liner material. The volume leaking through the liner enables a better understanding of the level of risk to groundwater. Using various aquifer parameters and basic hydrogeological equations it is possible to estimate the travel time through an aquifer between two points i.e. the time it would take for leachate leaking from a landfill to travel from that point to a receptor such as a well or surface watercourse. For example, using Darcy's Law the vertical movement of water in the bedrock will occur at a rate of 432m³/d while horizontal movement will occur in the order of 4000m³/d. These figures are based on clay wit ha permeability of 10^{-7}m/s underlying the site. As discussed in Section 2.1.1 above the presence of gravels beneath the site would significantly increase the travel times of groundwater and hence would increase the risk to individual wells and the aquifer as a whole.

The EIS includes a qualitative risk assessment but does not include any calculations or quantification of risk as per the EPA Landfill Manuals. The EIS indicates that a significant amount of site investigations were undertaken (including drilling, pumping tests, geophysics, packer testing etc)

however, the associated data on aquifer parameters was not used to quantify the risk or to establish the likelihood of contamination arising based on basic and fundamental hydrogeological methods. The EIS has failed to implement such risk calculations for the proposed Fingal landfill and it is therefore not possible to ensure that no risk of contamination exists.

3.0 SUMMARY

While the EIS contains a large amount of technical information on the site, there are a number of deficiencies and inadequacies with the way this data has been presented and interpreted.

The main items of concern are:

- The proposed location of the landfill on the only productive bedrock aquifer in Co. Dublin as delineated by the EPA.
- The lack of clarity on the bedrock formations directly underlying the landfill footprint and the consequence of this for the understanding of the hydrogeological environment.
- The lack of consideration of the gravel deposits directly underlying the proposed landfill footprint.
- The inadequate assessment of the impact on downgradient groundwater supplies in the area and on the reliance of the local food production industry on groundwater.
- The failure to consider the impact on the future potential use of the aquifer for public supply.
- The absence of a quantitative risk assessment of the potential impact of the proposed landfill as per the EPA Landfill Manual and no details on calculation of travel times within the aquifer.
- Absence of a site specific vulnerability map based on drilling and geophysical data
- Lack of suitable mitigation or investigation of the increase in suspended solids that will result during the construction phase (no design for attenuation ponds)
- The risk posed to the Bog of the Ring Public Supply Scheme and the lack of investigation of this risk
- The importance of the aquifer resource underlying the landfill footprint and the risk posed to the future use of this resource
- Contradictions in well survey information regarding wells downgradient of the landfill
- The lack of detailed assessment of groundwater discharges in the catchment

It is recommended that the following information would be required as a minimum before it is possible to make an informed planning decision on the development and to allow for a sufficient understanding of the potential risks:

- Site specific maps for depth to bedrock and aquifer vulnerability
- A geological map of the bedrock formations beneath the site based on published information and site specific information obtained from drilling logs

- Design of attenuation ponds to mitigate against risk of increased suspended solid loads during construction
- Review of report on the Bog of the Ring Public Supply currently being prepared for Fingal County Council by TES Consultants
- Assessment of the groundwater potential of the aquifer resource
- Detailed well survey of all properties at risk
- Understanding of groundwater discharges
- Time of travel calculations between landfill footprint and aspects of the water environment considered to be potentially at risk
- Estimation of the volume of leakage likely to arise through the mineral liner as per the guidelines in the EPA Landfill Design Manual Appendix C3

The main conclusions of the review of Section 3.18 of the EIS are as follows:

- The strategic importance of this aquifer in meeting current and future water requirements should be considered in the context of the risk posed by the proposed Fingal Landfill
- The sterilisation of this aquifer should the proposed landfill be constructed.
- The significant number of high yielding wells abstracting from this aquifer in the region of the proposed landfill that were not identified through the EIS. These wells reinforce the importance of this aquifer.

REFERENCES

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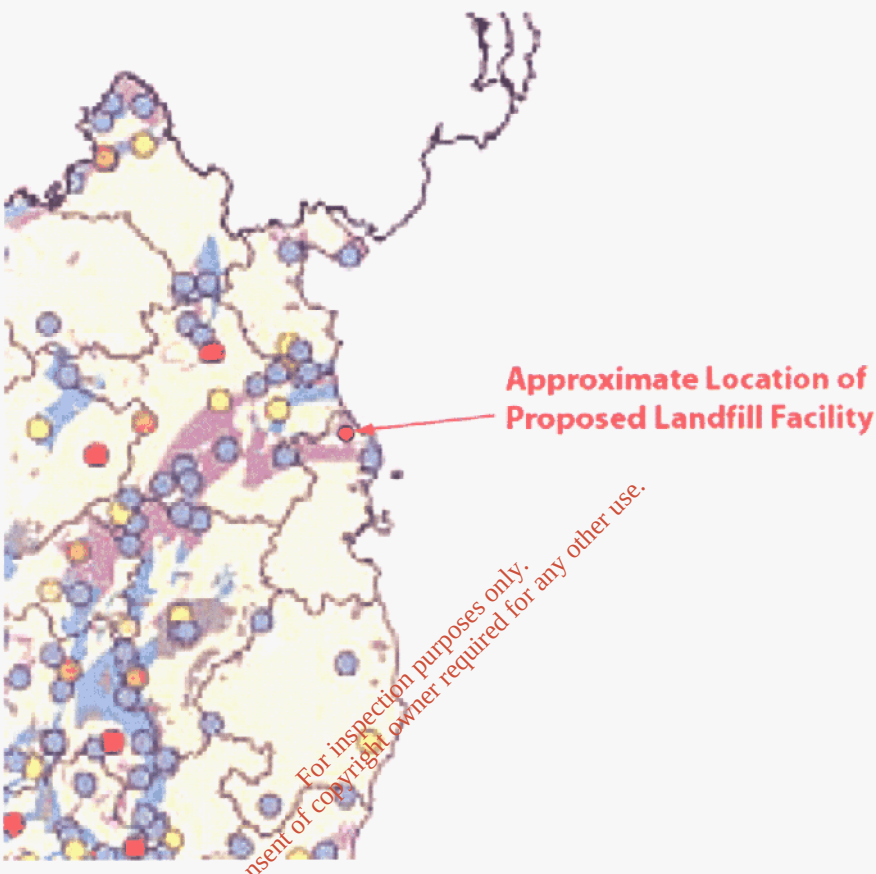
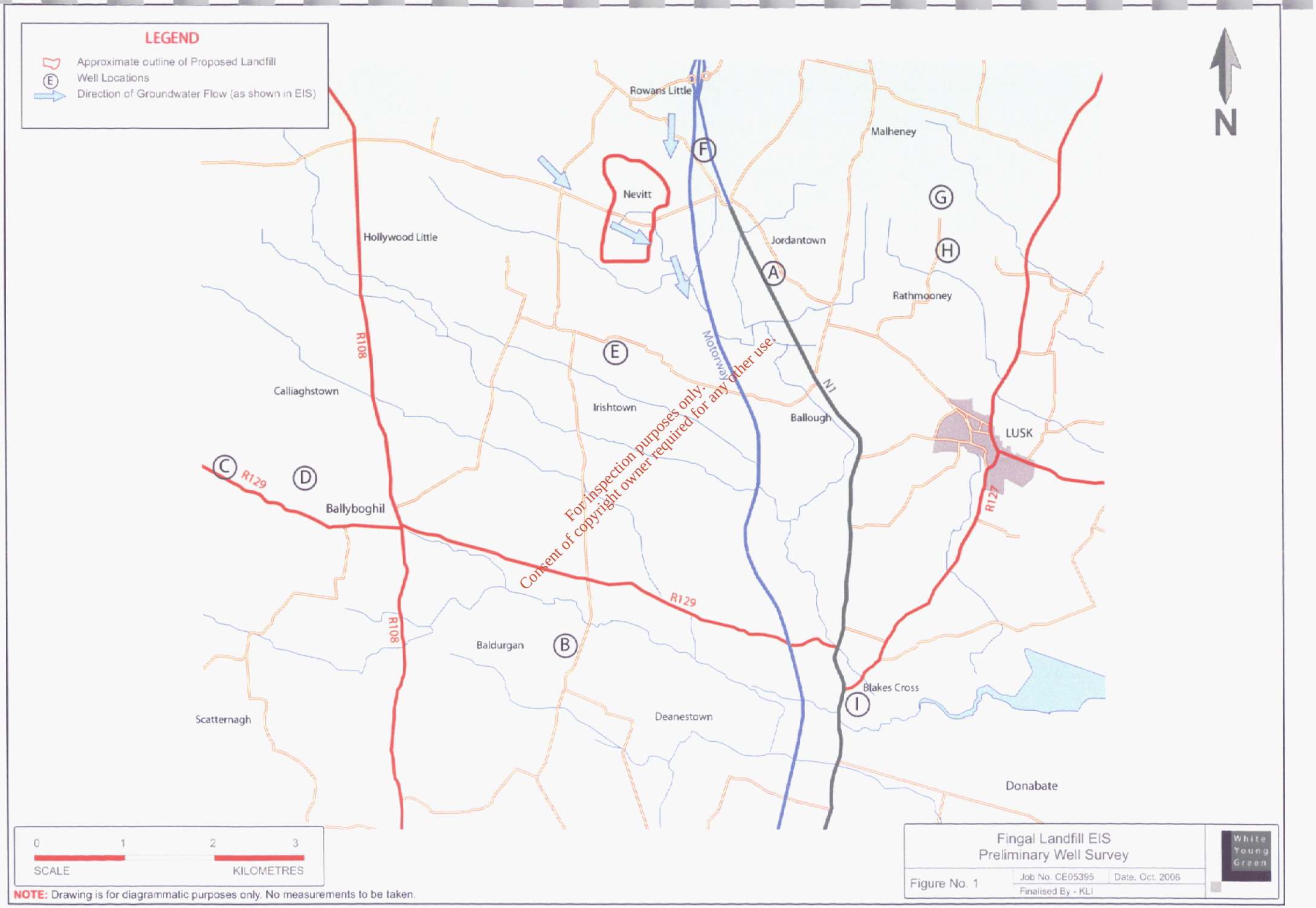
APPENDIX



Extract of Map published in 'Water Quality in Ireland 2005; Key Indicators of the Aquatic Environment' published by the EPA

Note: The purple area denotes 'productive fissured bedrock aquifer'



Data handling procedures in the aquifer classification process.

The characteristics of each aquifer category are shown separately overleaf.

Is the unit gravel or bedrock?

Bedrock

Decide on the extent of the rock unit to classify. Usually consider the rock unit across a whole structural region.

Collate available quantitative data for the geological unit (i.e. T, QSC, excellent yields, and high spring flows)[1].

Are there enough data to base classification on quantitative data alone? (As a guide, 10-20 points required, depending on area and complexity).[2]

Yes

If the data suggest there are distinct areas where the aquifer category changes, split the unit. Use catchment or county boundaries if split cannot be made on the basis of obvious lithological or structural boundaries.

Use hard data as the basis for aquifer classification (**see table overleaf**)

No

Can amount of data be enhanced using data from other formations?

Yes

Combine data. Use formations which are: stratigraphically 'close', lithologically similar , and structurally similar.
e.g. Lower Palaeozoics or 'Calp' equivalents.

No

Use assumptions based on lithology, structure, and hydrographs in conjunction with available hard data (see table overleaf).

Gravel

Do particle size and in situ field test data (if available) indicate the permeability is sufficient for an aquifer?

No → Non aquifer

Yes

Aquifer classification largely depends on the area of the gravel 'outcrop' where the saturated thickness exceeds 5m, or, if insufficient data on water levels is available, on the area where the total gravel thickness exceeds 10m. Gravels smaller than 'Locally Important' are considered non-aquifers, though they might be considered in the context of yields in bedrock aquifers.

Regionally Important:
Area normally > 10km^2.

Some validation in the form of particle size, pumping test, or borehole log data is required (the latter to assess continuity, thickness and extents).

Locally Important:
Area normally > 1km^2.

Smaller gravels can be included if saturated thickness is generally in excess of 5m and where:

i) increased recharge is expected to compensate for smaller area, and/or
ii) long term abstraction/Spring flow data is confirmatory.

The issue of enhanced recharge requires particular consideration where gravels of sufficient thickness are adjacent to large rivers with substantial summer flows.

1. 'T' is aquifer transmissivity, measured in m^2/d. QSC refers to the borehole's productivity index. This ranges from I (best) to V (worst).Excellent yields are >400 m^3/d. High spring yields are >2.160 m^3/d.

2. The amount of data that is 'enough' cannot be rigorously specified. However, 10-20 QSC points or 10-20 T points should be sufficient. The numbers required will be at the higher end of this scale for aquifers with large outcrop areas (in the hundreds of square kms) and where the data is widely scattered across a number of T or QSC categories. Extra care should be taken where a number of data points have been taken from one site. Usually, one representative value should be taken from such a site, but the whole data set from the site may be taken if the variability appears to match the variability across the unit(s) as a whole. Well yields and spring flows: only the presence of excellent yields and/or high spring flows is a consideration in terms of 'hard data' (i.e. the distribution of yield and spring data points across a variety of categories is not a significant influence on aquifer classification). As such, once there is a sufficient number of QSC or T points, the number of yield and spring data points which are also available is usually not an issue.

Aquifer Category (see over for codes)	T values (m^2/day)	Productivity	Borehole Yields	Potential extent of flow systems	Large springs	Lithology			Structure	Surface water discharge zones in areas of thin or free draining subsoil.	Annual fluctuation in water levels
						Type	Dolomitic	Karst features			
Rf	Most >50. Several >500	Mostly I & II	Excellent yields very common	Regional	Potentially	Thin bedded sandstones, limestones volcanics	Potentially	Little or none	Volcanics and thick bedded limestones generally highly fractured	Lowland drainage density < 0.5 km/km^2 Annual baseflow > 60% annual river flow. Low flows > 2 $l/sec/km^2$ and low flows > 20% average flows (Rk_d may have lower low flows).	Generally <10m
Rk_d	Variable. A few >500	Mostly I & II but fair proportion may be lower	Excellent yields very common	Regional	Potentially	Pure or dolomitic limestones	Potentially	Abundant	Thick bedded limestones generally highly fractured		Generally <15m
Rk_c	Variable. A few >500	Probably all classes, average may be III	Extremely variable	Regional	Potentially	Pure limestones	Potentially	Abundant	Thick bedded limestones generally highly fractured		Often > 15m
Lm	Some >50. A few >500	Average III	Excellent yields very common	Regional to local	Potentially	Pure limestones, thin-bedded sandstones, volcanics	Potentially	Occasional	Volcanics and thick bedded limestones generally highly fractured		No criteria
Lk	As for Rk_c or Rk_d	As for Rk_c or Rk_d	As for Rk_c or Rk_d	Local	No	As for Rk_c or Rk_d	As for Rk_c or Rk_d	As for Rk_c or Rk_d	As for Rk_c or Rk_d	No criteria	As for Rk_c or Rk_d
Ll	Some >50. A few >500	Average III - IV, some II	Some excellent yields	Local (occasionally longer along fault zones)	Perhaps but unusual	Impure limestones, sandstones, shales, others	Perhaps, but not extensive	Occasional (in limestones)	No criteria	High drainage density, low baseflows	No criteria
Pl	Most <50. One or two >500	Mostly V & IV, some III	Excellent yields very rare if any	Local	No	Impure limestones, sandstones, shales, others	No	None	No criteria	Values will be complicated by upland climatic setting and steep slopes.	No criteria
Pu	<50	Mostly V & IV	No excellent yields. Good yields rare if any	Very localised	No	Impure limestones, sandstones, shales, others	No	None	No criteria		No criteria

- "Excellent" well yields defined as >400 m^3/d. "Good" well yields defined as >100 m^3/d but less than 400 m^3/d.
- Productivity class ranges from I to V. Class I implies that significant quantities of groundwater can be abstracted with little consequent drawdown of the groundwater level in the borehole. A productivity class of V indicates that the drawdown of the groundwater level in a borehole can be significant for a given abstraction rate.
- The amount of groundwater recharge, and the degree of aquifer connectivity/compartmentalisation, are considered as additional factors when determining the aquifer classifications.

There are eight aquifer categories defined in *Groundwater Protection Schemes* (DELG/EPA/GSI, 1999), and they are as follows:

Regionally Important (R) Aquifers

- Karstified bedrock (**Rk**)
- Fissured bedrock (**Rf**)
- Extensive sand & gravel (**Rg**)

Locally Important (L) Aquifers

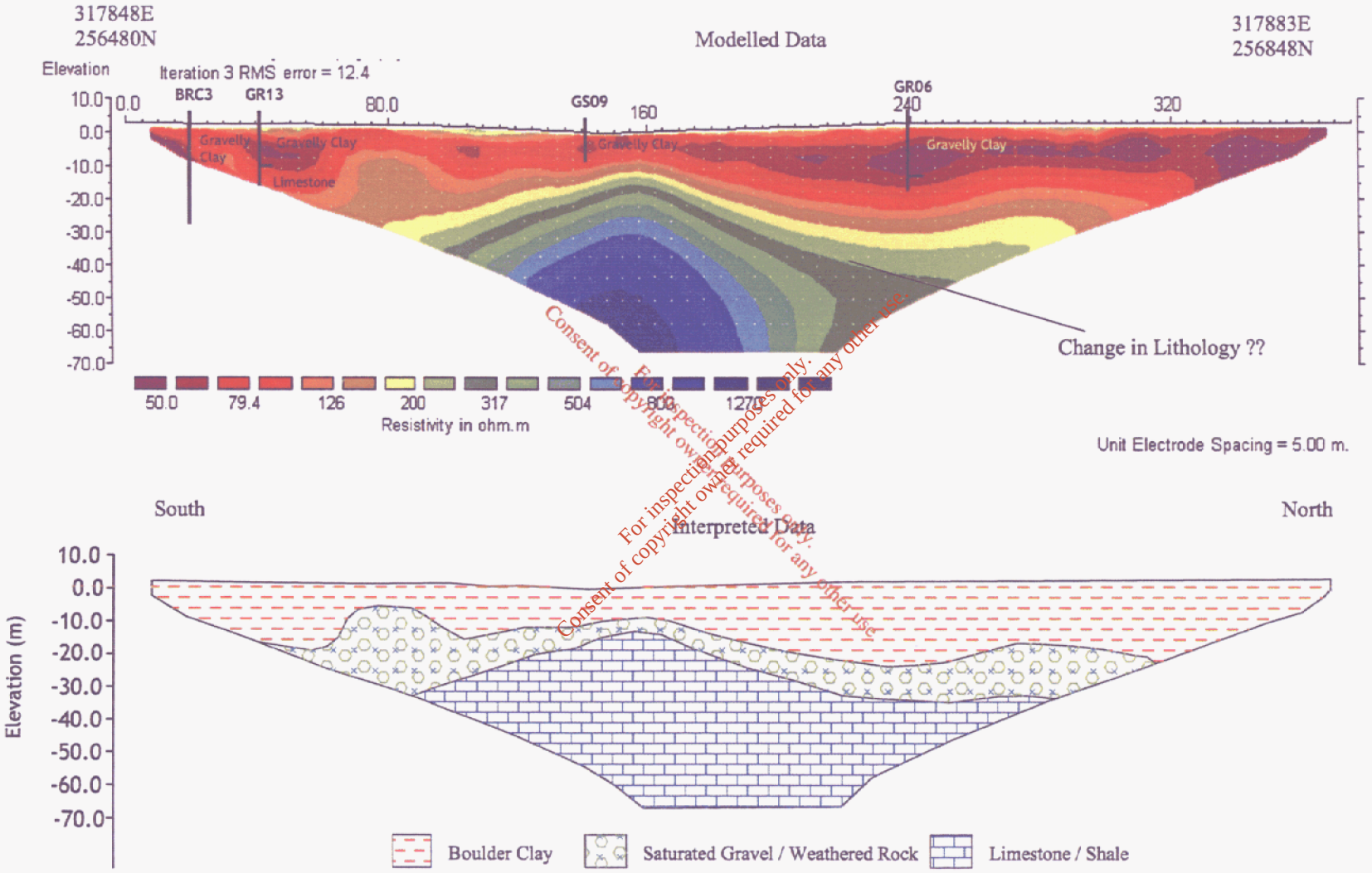
- Sand & gravel (**Lg**)
- Bedrock which is Generally Moderately Productive (**Lm**)
- Bedrock which is Moderately Productive only in Local Zones (**Ll**)

Poor (P) Aquifers

- Bedrock which is Generally Unproductive except for Local Zones (**Pl**)
- Bedrock which is Generally Unproductive (**Pu**)

Note that during the course of the National aquifer delineation for the Water Framework Directive, a further aquifer category was established: **Lk** – locally important karstified bedrock. Regionally important karstified bedrock aquifers (**Rk**) may, depending on the degree and nature of the karstification, be further characterised as either $\mathbf{Rk}_c$ – dominated by conduit flow or $\mathbf{Rk}_d$ – dominated by diffuse flow.

2D-Resistivity Profile 1A (EIS_2005)



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Drg No: 1492/2005/R1A

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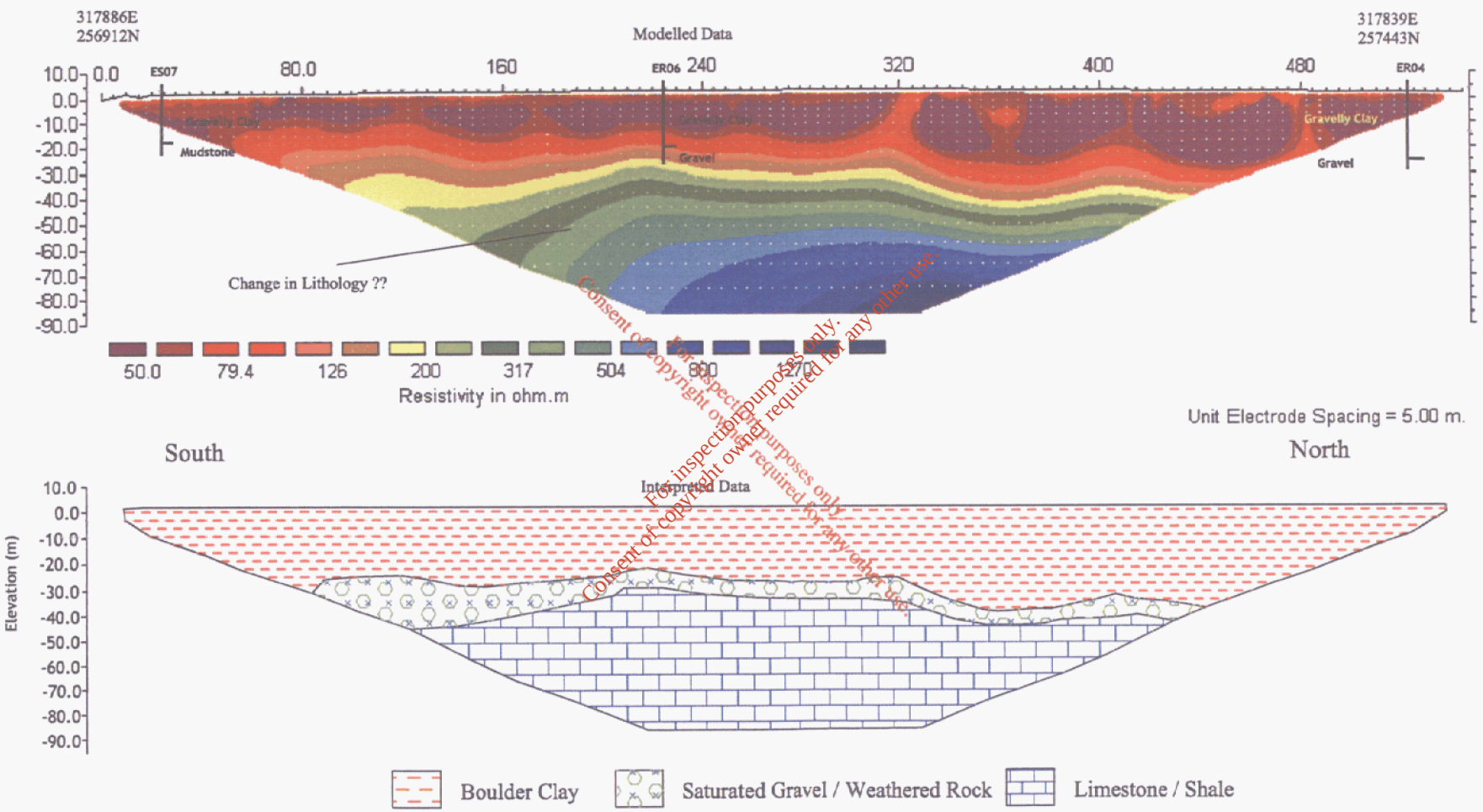

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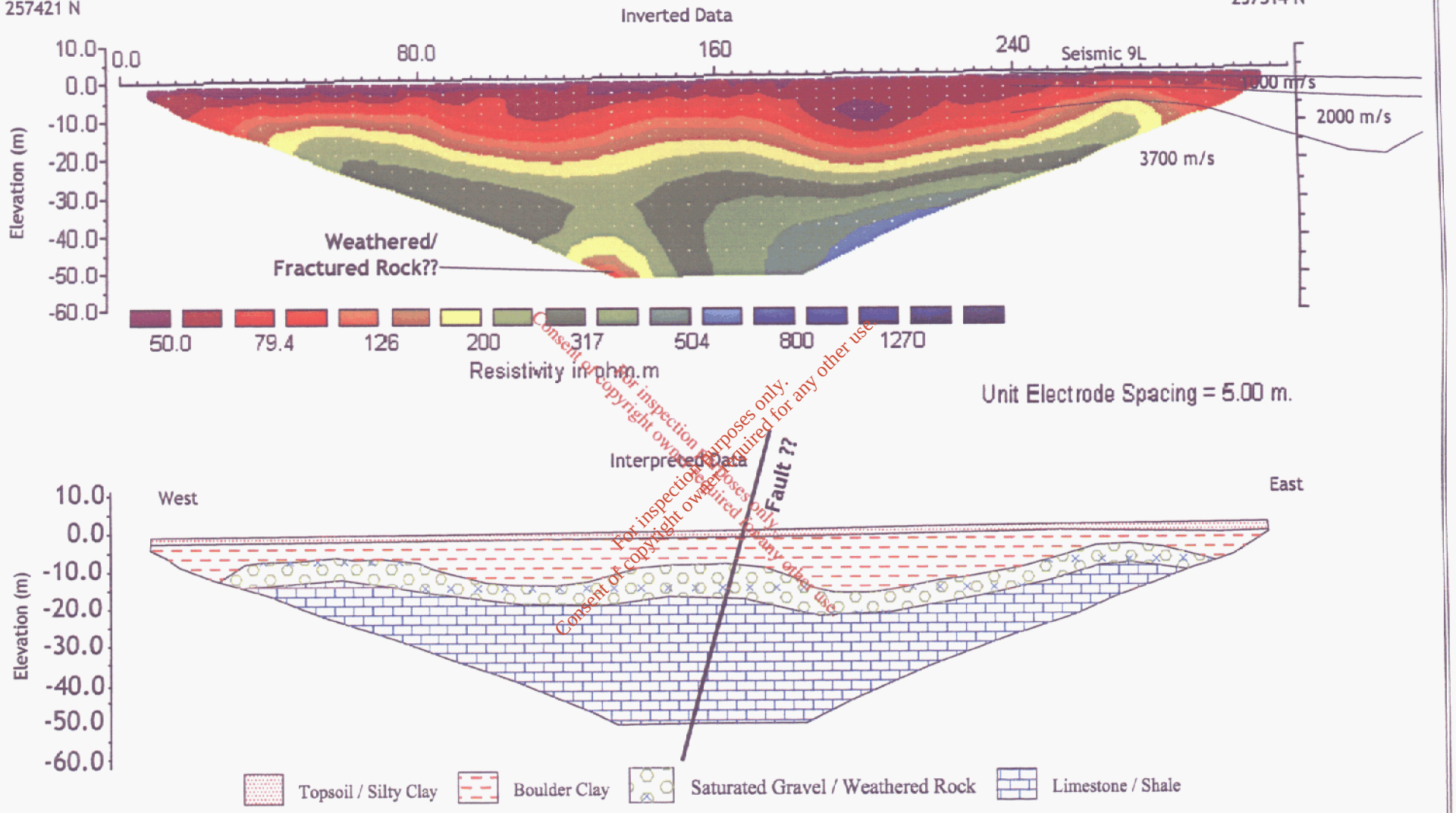
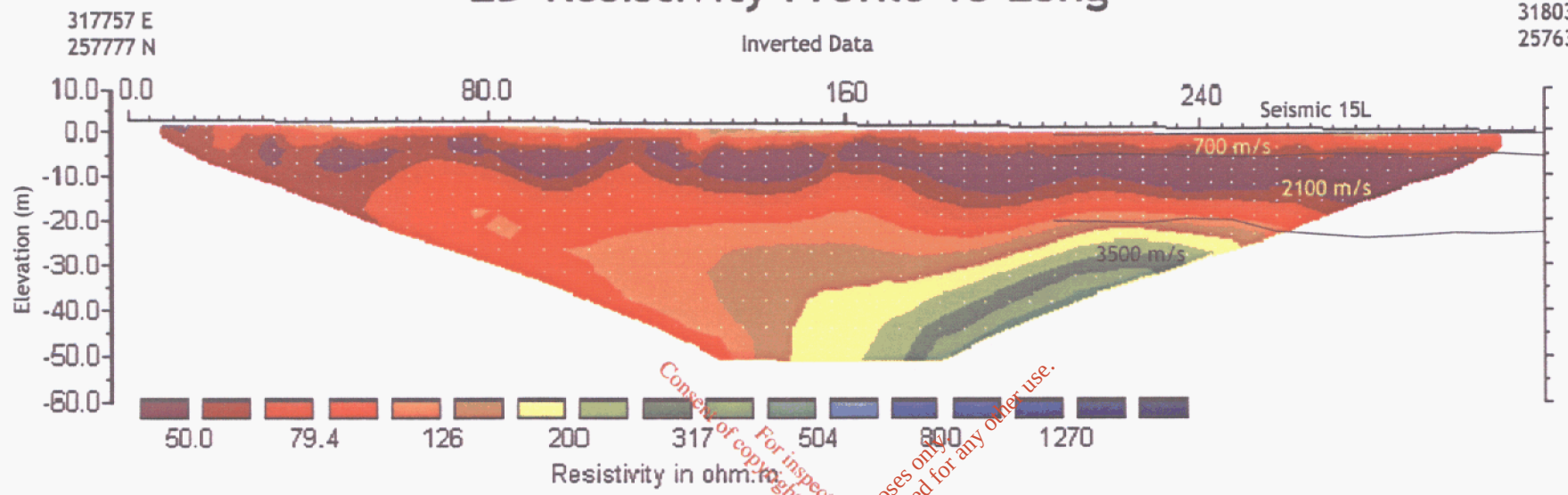
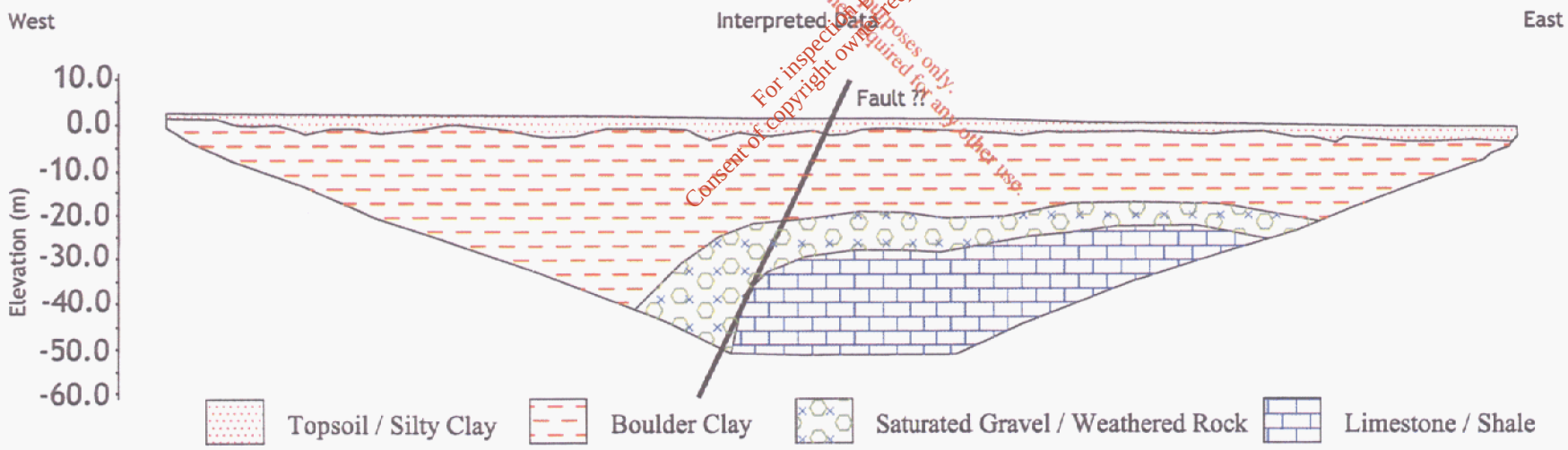
2D-Resistivity Profile 9 Long



BMA GeoServices Ground Engineering Consultants Comhairleoiri Cré-innealtóireachta BMA, Strawhall Business Park, Athy Road, Carlow, Ireland. Phone: 353-59-9134488 Mobile: 087-2477923 Fax: 353-59-9134480 E-mail: bmacarlow@bma.ie	RMS ERROR 1.4 %	Drawn: Kevin Galvin Design: KA Date: June 2004 Checked: James Hodgson Issued On:	SECTION 9 LONG INTERPRETATION 2D-RESISTIVITY PROFILE 9 LONG	FINGAL LANDFILL SITING STUDY (SITE B)	RPS-MCOS	Drg No: 1492/09 BMA GeoServices Ground Engineering Consultants Comhairleoiri Cré-innealtóireachta BMA, Strawhall Business Park, Athy Road, Carlow, Ireland. Phone: 353-59-9134488 Mobile: 087-8165810 Fax: 353-59-9134480 E-mail: bmacarlow@bma.ie

2D-Resistivity Profile 15 Long





BMA GeoServices Ground Engineering Consultants Comhairleoirí Cré-Innealtóireachta BMA, Strawhall Business Park, Athy Road, Carlow, Ireland. Phone: 353-59-9134488 Mobile: 087-2477823 Fax: 353-59-9134490 E-mail: bmacarlow@bma.ie	RMS ERROR 1.9 %	Revision Details	Drawn: Kevin Galvin Scale: NA Date: June 2006 Checked: James Hodgson Based On:	SECTION 15 LONG INTERPRETATION 2D-RESISTIVITY PROFILE 15 LONG	FINGAL LANDFILL SITING STUDY (SITE B)	RPS-MCOS	Drg No: 1492/15 BMA GeoServices Ground Engineering Consultants Comhairleoirí Cré-Innealtóireachta BMA, Strawhall Business Park, Athy Road, Carlow, Ireland. Phone: 353-59-9134488 Mobile: 087-8105810 Fax: 353-59-9134490 E-mail: bmacarlow@bma.ie