Eve O'Sullivan

Subject: FW: H0306-01 Carlingford Landfill
Attachments: tier 2 finalRev A.pdf

From: Pamela Dagg [mailto:pamela.dagg@louthcoco.ie]
Sent: 23 July 2018 15:11
To: Magnus Amajirionwu
Subject: RE: H0306-01 Carlingford Landfill

Magnus

Completed tier 2 document.

Kind regards
Pamela
Direct Line 042 9392926, locall: 1890202303

Cuirfear fáilte roimh chomhfhreagras Gaeilge

Visit our website at www.louthcoco.ie

Think before you print.

From: Magnus Amajirionwu [mailto:M.Amajirionwu@epa.ie]
Sent: 18 July 2018 10:25
To: Pamela Dagg
Subject: H0306-01 Carlingford Landfill

Hi Pamela,

Thanks for taking my call earlier.

Please find following, documents I would require in relation to the CoA application:

- Application form completed for H0306-01 by the Louth CoCo.
- Tier 1, 2 and 3 Risk Assessments
- Monitoring results for:
  - Leachate
  - Surface and groundwater
  - Landfill gas
- Any other associated documents

Thanks and kind regards

Magnus

Dr. Magnus U. Amajirionwu
Scientific Officer
Office of Environmental Sustainability
Environmental Protection Agency,
Johnstown Castle, Wexford, Ireland

T. +353 539160600 | E. a.magnus@epa.ie
www.epa.ie

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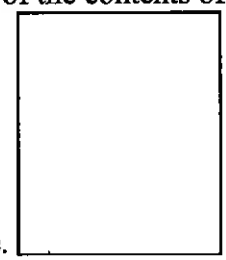

Granary House
Rutland Street
Cork

Tel. [021]4321521
Fax. [021]4321522

Tier II Detailed Site Investigation
And
Quantitative Risk Assessment

Former Landfill

Carlingford Town,

County Louth

Prepared For:

Louth County Council,
County Hall,
Millennium Centre,
Dundalk.

Prepared By: -

O' Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork.

14th October 2013

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APPENDICES

1. INTRODUCTION

Louth County Council (the Council) completed a Tier 1 Assessment of the closed Landfill at Carlingford in accordance with the "Code of Practice Environmental risk Assessment for Unregulated Waste Disposal Sites (CoP)" published by the Environmental Protection Agency (EPA).

The Tier 1 Assessment concluded that the site was a Class A – High Risk site, due the potential for leachate migration to surface water and landfill gas to human receptors. The Council completed a Tier 2 Site Investigation and appointed O'Callaghan Moran & Associates (OCM) to review the Tier 2 Investigation data and prepare the Tier 2 Report.

1.1 Work Scope

The Tier 2 Assessment comprised a Site investigation that included:

- A trial pit programme to determine the lateral and vertical extent of the fill area, the nature of the waste and confirm the presence and nature of underlying subsoil.
- The installation and monitoring of landfill gas wells.
- The collection of waste samples for chemical analysis and characterisation.
- The collection of samples of the natural subsoils underlying the waste and the capping material for geotechnical analysis.
- The collection of groundwater samples.
- The collection of surface water samples.
- The completion of a geophysical survey
- Landfill gas monitoring in landfill gas wells and buildings.
- The completion of a biological assessment of an adjacent stream.

2. SITE DESCRIPTION

The former Carlingford Town Landfill is located at the south eastern edge of Carlingford town on the LS7062 (Figure 2.1). It covers an area of 1.44 Ha. It is not known when the landfill opened but it ceased to operate as a landfill in 1984 when the Whiteriver landfill was opened.

The Tier 1 assessment states that waste was collected once a week in Carlingford by Louth County Council and was deposited on site. The old method of dump and burn was deployed in the landfill. A stream flows along the western site boundary. There is a public water well located approximately 50m from the southwestern site boundary.

The sewage treatment plant for Carlingford is located in the southern section of the site. Prior to the development of the site waste from beneath the development area was excavated and re-deposited within the landfill further to the north. No waste is visible on the surface of the site as the majority of the site has been capped with soil and the area around the wastewater treatment plant has been landscaped.

2.1 Surrounding Land Use

The general area surrounding the site is a mix of residential and agricultural land use. There is a housing estate which is still being constructed 50m to the west of the site and agricultural lands to the south and east of the site. To the west there is a Bed & Breakfast and further west there is a retirement/nursing home. The area is secured with a chain link fence and gate around the site. Carlingford Lough is located within 500m of the site.

O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com

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Louth County Council

TITLE

Site Location

Legend

FIGURE No.

2.1

SCALE

2.2 Geology and Hydrogeology

Information on the local and regional geology and hydrogeology was derived from a desk study, which included Geological Survey of Ireland (GSI) databases; Teagasc Soil Maps for the region; and the site investigations carried out on site. The latter, which included the excavation of trial pits and installation of landfill gas monitoring wells, is described in more detail in Section 3.

2.2.1 Soils and Subsoil

The subsoils distribution, which is based on the Teagasc maps, is shown on Figure 2.2. The site is described on the Teagasc map as being underlain by marine sands and gravels (**MGs**). There is a small section in the east of the site which is underlain by lower Palaeozoic sandstone and shale derived till (**TLPSsS**).

The subsoils encountered beneath the waste during the investigation comprised low permeability brown or grey silt/clay. The landfill gas monitoring well logs indicate that the waste material is underlain by a pale blue grey silt/clay. This clay ranged in thickness from 0.5m (BH-5) to 2.1m (BH-1). The clay is underlain by sands and gravels.

2.2.2 Bedrock

The bedrock geology is shown on Figure 2.3. The site is underlain by Dinantian Mixed Sandstones, Shales and Limestones. Bedrock was not encountered during the investigations.

2.3 Hydrology

There is a steam on the western site boundary. The stream is culverted upstream of the site. On the 1860's six inch map the stream is depicted as rising approximately 50m to the south of the site. The stream discharges from a culvert pipe into an open channel at the southern boundary of the site. The stream flows to the north and discharges to Carlingford Lough approximately 500m from the site.

2.4 Hydrogeology

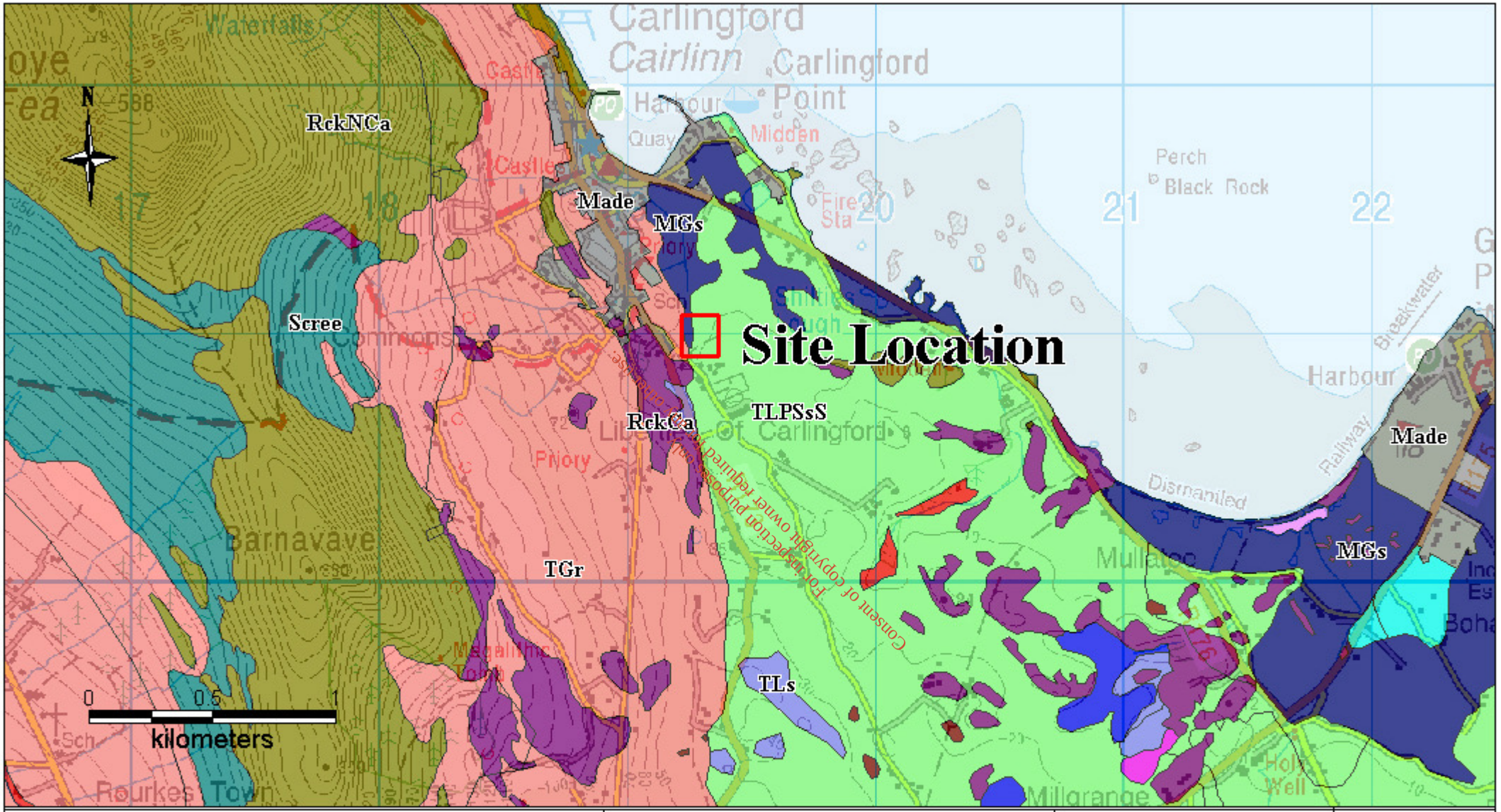
2.4.1 Aquifer Classification

Based on the Draft GSI source protection report of the Carlingford Groundwater Supply Boreholes (Appendix 1) the site is underlain by a locally important gravel aquifer (**Lg**).

The GSI has developed a classification system for aquifers based on the value of the resource and the hydrogeological characteristics. The bedrock aquifer beneath the site is characterised by the GSI as a locally important aquifer which is moderately productive (**Lm**), as shown on Figure 2.4.

2.4.2 Aquifer Vulnerability

Vulnerability is defined by the GSI as the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. Vulnerability categories range from Extreme (**E**) to High (**H**) to Moderate (**M**) to Low (**L**) and are dependant on the nature and thickness of subsoils above the water table. The GSI Vulnerability Map (Figure 2.5) indicates that the vulnerability across the site is High (**H**).



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
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Subsoil Classification

Legend

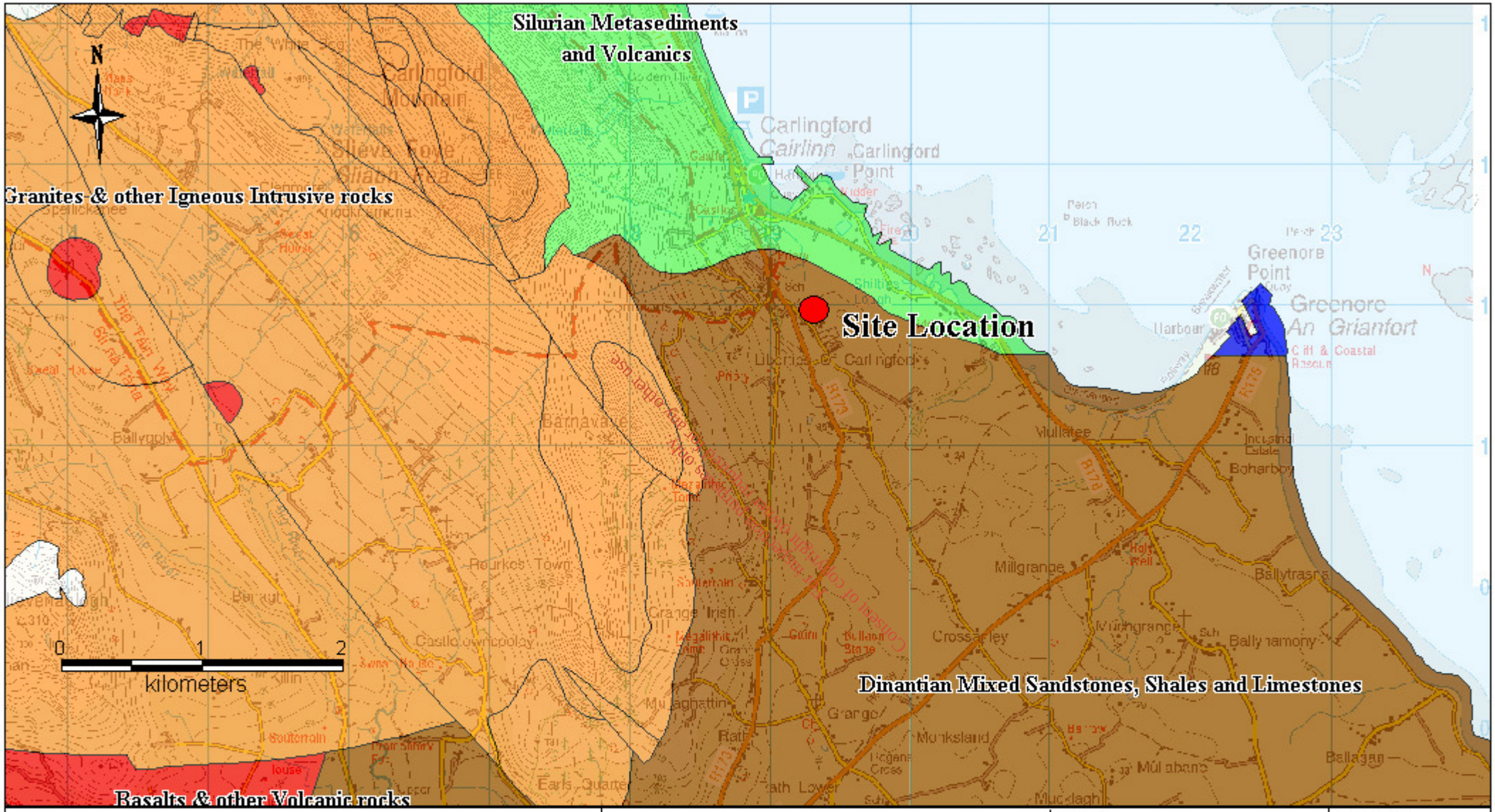
Subsoil Classification

- MGs
- Made
- TLPSsS
- RckCa
- TGr
- Scree
- A

FIGURE No.

2.2

SCALE



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
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Bedrock Geology

Legend

Bedrock Geology

- Dinantian Mixed Sandstones, S
- Dinantian Pure Bedded Limest
- Granites & other Igneous Intru
- Silurian Metasediments and Vo
- Basalts & other Volcanic rocks
- all others

FIGURE No.

2.3

SCALE

2.4.3 Groundwater Flow Direction

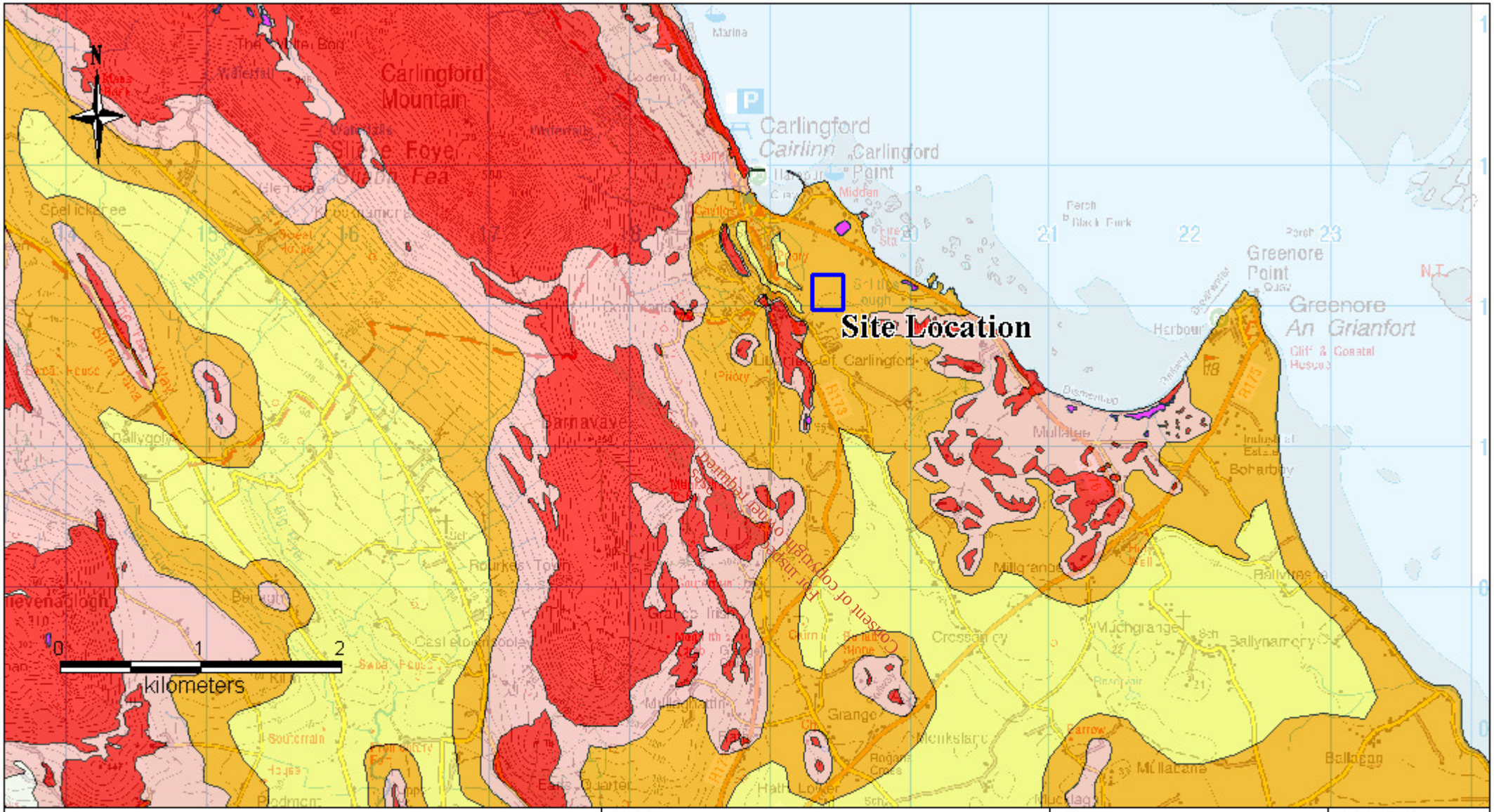
The local groundwater flow direction is considered to follow the local topography, moving to the north towards Carlingford Lough.

2.4.4 Nearby Wells

There is an on site groundwater monitoring well in the western section of the site. The water supply for Carlingford town is derived from an abstraction well located approximately 55m to the south west of the site. The well is situated up-hydraulic gradient of the site. Based on the Draft GSI source protection report of the Carlingford Groundwater Supply Boreholes the site is underlain by a locally important gravel aquifer (**Lg**). This aquifer is the water source for the Carlingford borehole. The source protection zone extends into the landfill area. While the semi-analytical equations used to establish the lateral extent of the boundary indicate that the boreholes would draw water from up to 50m distance down gradient of the source which would not extend into the landfill area. However, a conservative approach as taken in determining the extent of the source protection area. This approach means that a precautionary arbitrary distance of 100m is used to allow for errors and variability in the aquifer parameters".

2.5 Protected Areas.

The landfill is hydraulically upgradient of the Carlingford Shore SAC and Carlingford Lough SPA. There is a stream that flows from the site into Carlingford Lough.



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
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Aquifer Vulnerability

Legend

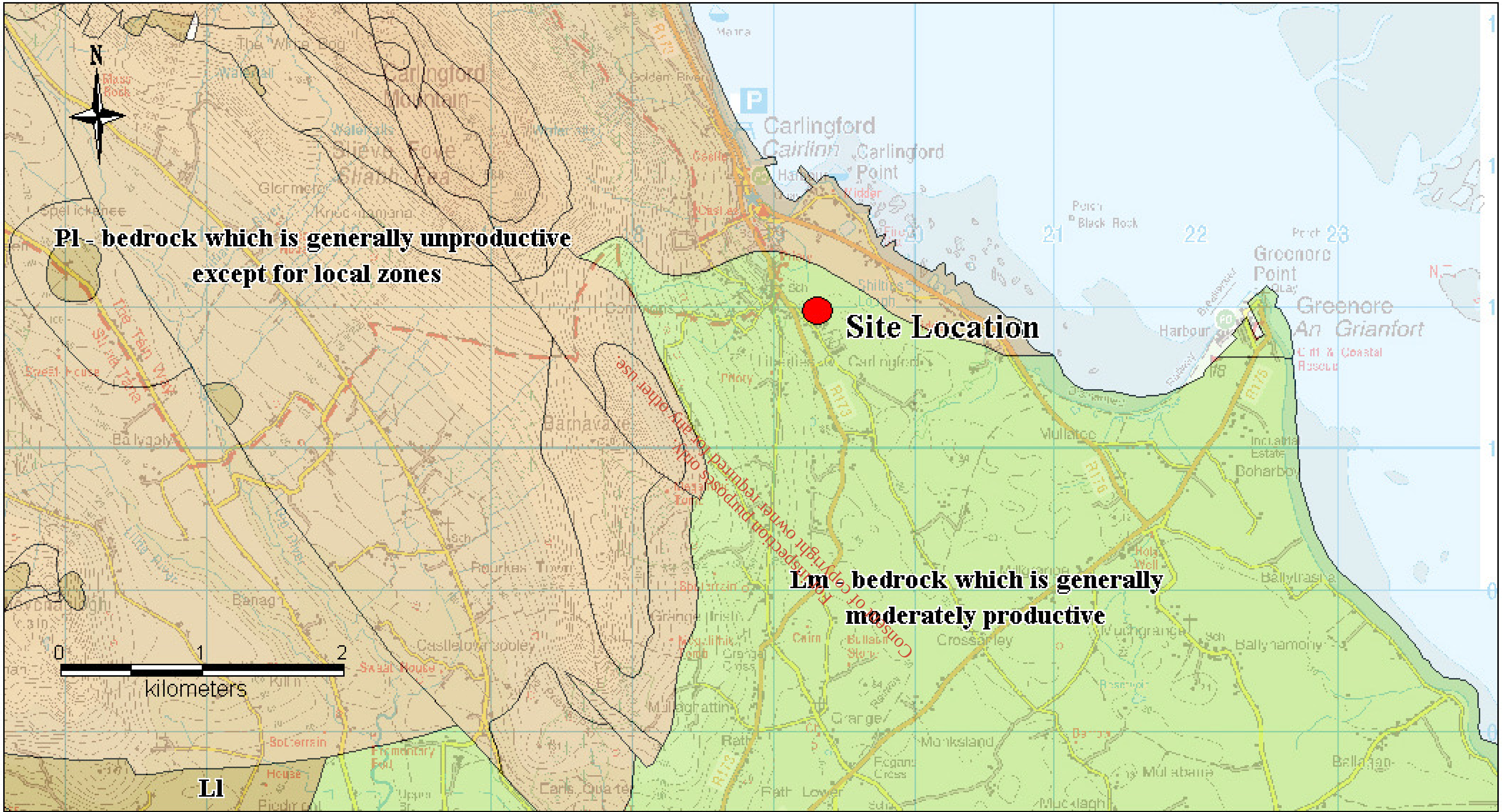
Aquifer Vulnerability

- E - Extreme
- H - High
- M - Moderate
- X - Rock at Surface
- W - Water

FIGURE No.

2.5

SCALE



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
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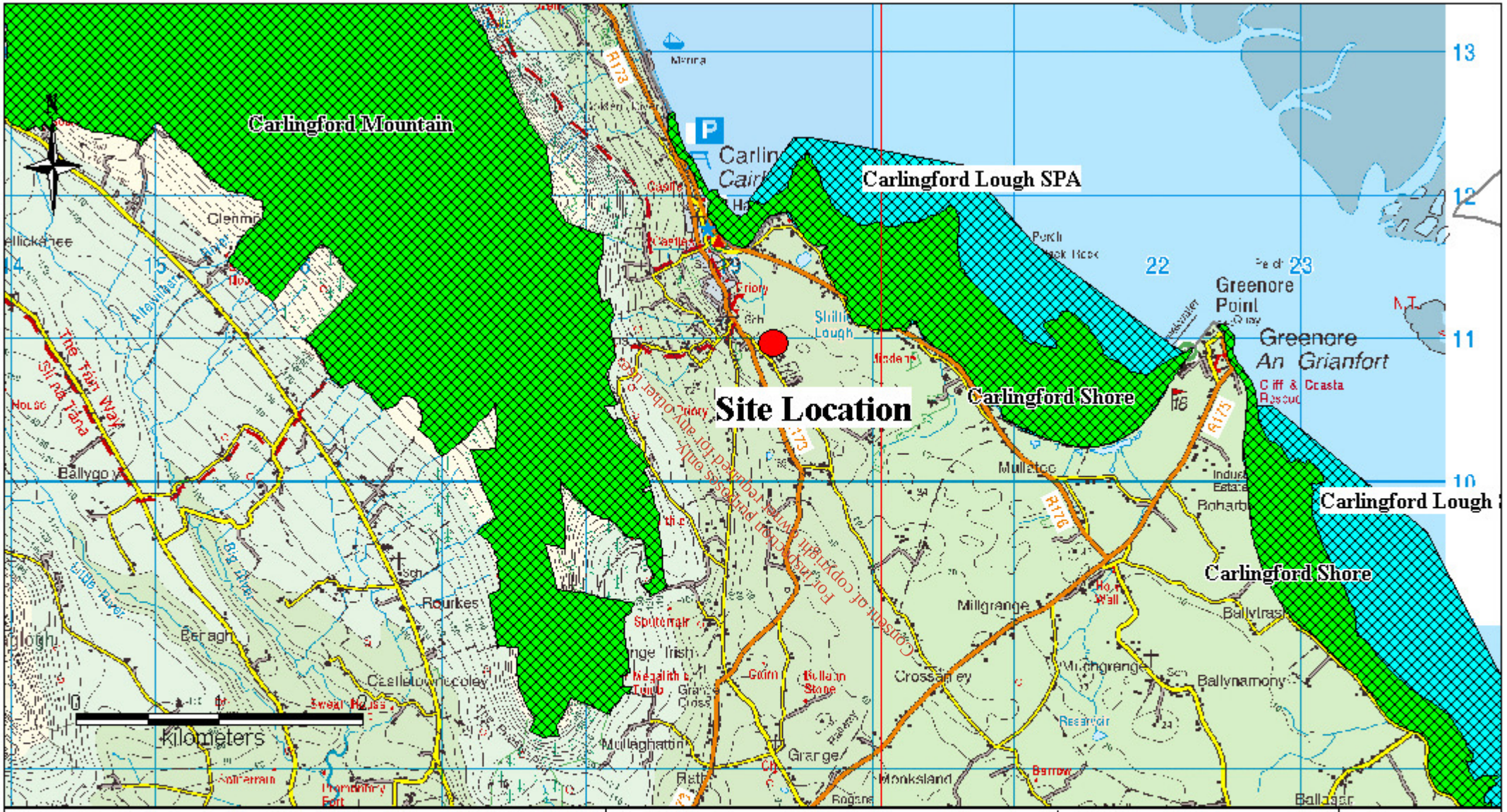
Aquifer Classification

FIGURE No.

2.4

SCALE



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
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Protected/Designated Areas

Legend

SPA

SAC

FIGURE No.

2.6

SCALE

3. SITE INVESTIGATION

A site investigation was completed by Louth County Council (LCC) between the 22nd October and 15th December 2009.

Apex Geoservices completed a geophysical survey on site in December 2009.

AMC Environmental installed landfill gas well and completed gas monitoring surface water sampling and stream sediment sampling in January 2011.

The site investigation included the excavation of thirty three trial pits, landfill gas monitoring within trial pits and on site buildings, the collection of waste samples for laboratory analysis and the collection of samples of the subsoils beneath the waste for assessment of shear strength and permeability. Groundwater and surface water samples were also collected for laboratory analysis.

Landfill gas wells were installed on site between the 11th and 13th January 2011. Gas monitoring was undertaken in the wells.

3.1 Trial Pit Excavation

The objective of the trial pits was to assess the vertical and lateral extent of the fill and to characterise the waste. The pits were excavated at the locations shown on Figure 3.1 using a mechanical excavator, supervised by a LCC representative. The pits were logged in accordance with BS5930 and the logs are presented in Appendix 2.

Thirty three trial pits were excavated across the site. Eleven trial pits were excavated between the 22nd and 23rd October 2009. Twenty two trial pits were excavated between the 14th and 15th December 2009. A layer of clay topsoil/infill was encountered in all trial pits. The layer of topsoil ranged in thickness from 0.2m to 1.8m. The topsoil was underlain by fill material comprised of plastic, brick, concrete, blacktop, glass bottles, timber, soil and stone as well as domestic waste such as clothes and burnt waste. The fill material was underlain by silt/clay. The depth to the top of the natural subsoils ranged from 1.5m to 4.2m.

Water inflows were noted in the base of TP-2, 3, 5 and 11. The water was noted at the interphase between the fill material and the underlying natural subsoils. The underlying subsoils were comprised of grey silt/clay. Leachate was encountered in TP-2, 13 and 14.

Hydrocarbon odours were noted in the fill material the trial pits TP-2 and 5. The fill material in TP-11 is described as having an oily odour. A review of the trial pit site investigation and the geophysical site investigation indicates that waste is not present across the entire site foot print of 1.4Ha. Prior to the development of the wastewater treatment plant the geophysical survey data indicates a waste footprint of approximately 1.15 Ha. Waste was removed from the southern section of the site for the development of the wastewater treatment plant. This resulted in a reduction of the waste foot print to approximately 0.92Ha.

3.2 Waste Characterisation

The waste and subsoils were visually assessed on site during the trial pitting exercise. The waste materials encountered comprised plastic, brick, concrete, blacktop, glass bottles, timber, soil and stone as well as domestic waste such as clothes and burnt waste. These materials are typical of a mix of municipal solid waste and construction and demolition waste.

3.2.1 Sampling Methodology

Waste samples were collected from TP-1, 2, 4 and 11 as these were deemed most representative of the wastes across the site. The samples were placed in laboratory prepared containers and stored in coolers to maintain sample temperature at approximately 4°C. Chain of custody (COC) documentation was completed and accompanied the samples to the Fitz Scientific laboratory in Drogheda, County Louth.

3.2.2 Laboratory Analysis

The samples were analysed for the full suite of parameters specified in the Annex to EU Council Decision establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC. The Annex, which is commonly known as the Landfill Waste Acceptance Criteria (WAC), sets threshold limits for a range of inorganic and organic parameters that characterise a waste as suitable for disposal to an inert, non-hazardous or hazardous waste landfill.

The solid samples were tested for Total Organic Carbon (TOC), BTEX (benzene, toluene, ethylbenzene and xylene) Polychlorinated biphenyls (PCB), Mineral Oil and Polycyclic Aromatic Hydrocarbons (PAH). Leachate generated from the samples was tested for arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, lead, antimony, selenium and zinc, chloride, fluoride, soluble sulphate, phenols, dissolved organic carbon (DOC) and total dissolved solids (TDS).

The analytical methodologies were all ISO/CEN approved or equivalent and the method detection limits were all below the relevant thresholds.

3.2.3 Laboratory Results

The full laboratory test report is in Appendix 3 and the results are summarised in Table 3.1. Included in the Table are the WAC for Inert and Non-Hazardous Waste.

Table 3.1 Waste Characterisation

Parameter	Unit	TP-1 29-10-2009	TP-2 22/10/2009	TP-4 22/10/2009	Inert Landfill	Non-Hazardous Landfill
Antimony	**mg/kg**	0.0476	0.0242	0.0529	0.06	0.7
Arsenic	**mg/kg**	0.1064	0.0968	0.123	0.5	2
Cadmium	**mg/kg**	0.0003	<0.00009	0.0002	0.04	1
Copper	**mg/kg**	0.2192	0.114	0.242	2	50
Chromium	**mg/kg**	0.0205	0.0245	0.0127	0.5	10
Lead	**mg/kg**	0.0083	0.002	0.0059	0.5	10
Nickel	**mg/kg**	0.0364	0.576	0.0748	0.4	10
Molybdenum	**mg/kg**	0.02489	0.168	0.404	0.5	10
Selenium	**mg/kg**	0.0201	0.0198	0.0234	0.1	0.5
Zinc	**mg/kg**	0.0118	0.0046	<0.0046	4	50
Mercury	**mg/kg**	<0.0002	<0.0002	<0.0002	0.01	0.2
Barium	**mg/kg**	0.2357	0.1594	0.418	20	100
Chloride	**mg/kg**	15.51	24.11	53.57	800	15,000
Fluoride	**mg/kg**	7.14	5.74	9.69	10	150
Sulphate*	**mg/kg**	230.94	187.59	609.13	1000*	20,000
Dissolved Organic Carbon	**mg/kg**	289	165	374	500	800
Total Dissolved Solids	**mg/kg**	1980	1580	3420	4,000	60,000
Phenols	**mg/kg**	0.06	0.07	0.1	1	NE
Total Organic Carbon	**%**	7.692	5.146	6.755	3**	NE
Benzene	**mg/kg**	<0.5	<0.5	<0.5	6	NE
Toluene	**mg/kg**	**Not analysed**	**Not analysed**	**Not analysed**	6	NE
Ethylbenzene	**mg/kg**	<0.5	<0.5	<0.5	6	NE
Total Xylene	**mg/kg**	<1	<0.5	<1	6	NE
PCB Total of 7	**mg/kg**	<0.005	<0.005	<0.005	1	NE
Naphthalene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Acenaphthylene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Acenaphthene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Fluorene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Phenanthrene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Anthracene	**mg/kg**	<0.02	<0.005	<0.005	NE	NE
Fluoranthene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Pyrene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Benzo(a)anthracene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Chrysene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Benzo(b)+Benzo(k)fluoranthene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Benzo(a)pyrene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Indeno(123cd)pyrene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Dibenzo(ah)anthracene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Benzo(ghi)perylene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Coronene	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Total 17 PAH's	**mg/kg**	<0.05	<0.005	<0.005	NE	NE
Mineral Oil	**mg/kg**	89.9	121.6	13.09	500	NE

NE - Not Established

- sulphate level exceeding inert waste limit may be considered as complying if the TDS value does not exceed 6,000mg/kg at L/S = 10l/kg.

**-a higher limit may be accepted provided the DOC value of 500mg/kg is achieved

The level of nickel detected in TP-4 was greater than the inert WAC but lower than the non-hazardous WAC limit. The level of TOC detected in all samples was greater than the inert WAC limit. A higher limit of TOC is accepted provided that a DOC level of less than 500mg/kg is achieved. The level of DOC detected in all samples was significantly lower than 500mg/kg.

Based on the results it is considered that the waste can be categorised as inert.

3.3 Groundwater Monitoring

3.3.1 Sampling Methodology

Groundwater samples were collected from the on site groundwater well on the 23rd November 2009. A sample was collected from the upgradient Carlingford Water Supply well on three occasions (16th February 2009, 30th November 2009 and 14th December 2009).

The samples were placed in laboratory prepared containers, stored in a cooler, and sent for analyses to Euro Environmental Laboratory (now Fitz Scientific) in Drogheda

3.3.2 Laboratory Analysis

The samples were analysed for a range of organic and inorganic parameters that included indicators of general water quality and leachate contamination. The laboratory methodologies were all ISO/CEN approved or equivalent and the method detection limits (MDL) were all below the relevant guidance limit.

3.3.3 Laboratory Results

The full laboratory test report is in Appendix 3 and the results are presented in Table 3.2. The table includes Interim Guideline Values (IGV) published by the EPA and the Groundwater Threshold Values (GTV) set out in the European Communities Environmental Objectives (Groundwater) Regulations (S.I. 9 of 2010). The IGVs are not statutory, but were developed to assist in the assessment of impacts on groundwater quality. The IGVs are based on, but are more conservative than the Drinking Water quality standards. GTVs have only been established for core indicator parameters while the IGVs provide a broader range of contaminant indicator parameters for risk assessment purposes.

With the exception of hardness all parameters in the upgradient Carlingford Public Supply Well were below the IGV and GTV.

The levels of iron, manganese, ammonia and total coliforms detected in the on site well were all higher than the IGV and GTV. The remaining parameters in the on site well were below the IGV and GTV.

Table 3.2 Groundwater Quality Data

Sample I.D. Sample Date	Units	DW_AUDIT 16-02-09	DW_AUDIT 30-11-09	DW_AUDIT 14-12-09	On Site Well 23-10-2009	IGV	GTV
Arsenic	µg/l	<1	<1	<1	<0.1	10	7.5
Barium	µg/l	-	-	<50	-	100	-
Boron	µg/l	<50	<50	-	112.9	1,000	750
Cadmium	µg/l	<0.1	<0.1	<0.1	<0.09	5	3.75
Copper	µg/l	2.8	6.9	3.7	1.7	30	1,500
Mercury	µg/l	<0.01	<0.01	<0.01	<0.03	1	0.75
Nickel	µg/l	-	-	-	1.6	20	15
Lead	µg/l	<1	<1	<1	1.2	10	18.75
Zinc	µg/l	-	-	-	1.4	100	-
Iron	µg/l	<50	<50	<50	1435	200	-
Selenium	µg/l	<1	1	1	-	-	-
Manganese	µg/l	<1	<1	<1	228.1	50	-
Calcium	mg/l	-	-	-	12.1	200	-
Magnesium	mg/l	-	-	-	0.6	50	-
Sulphate	mg/l	15.3	17.6	17.6	<1.39	200	-
Chloride	mg/l	18	16	17	17.55	30	24-187.5
Fluoride	mg/l	<0.150	<0.150	<0.150	<0.02	1	-
Total Alkalinity CaCO3	mg/l	-	-	-	48	NAC	-
Nitrite	mg/l	<0.002	<0.002	<0.002	-	0.1	0.375
Hardness	mg/l	236	240	272	-	200	-
Total Cyanide	µg/l	<10	<10	<10	<5	10	37.5
Chromium-	µg/l	1.9	7	2.6	2.7	30	37.5
Phosphorous	µg/l	<20	<20	<20	9	30	35
Potassium	mg/l	-	-	-	1.31	5	-
Sodium	mg/l	-	-	-	7.64	150	150
pH	pH units	7.4	7.3	7.5	-	6.5-9.5	-
Elect Conduct	µS/cm	527	495	541	162	1,000	800-1,875
Total Oxidised N	mg/l	-	-	-	<0.28	NAC	-
Ammonia	mg/l	<0.03	<0.03	<0.03	1.11	0.15	0.065-0.175
TDS	mg/l	-	-	-	19	-	-
TOC	mg/l	-	-	-	16	-	-
Atrazine	µg/l	-	-	-	<0.01	1	0.075
Dichloromethane	µg/l	-	-	-	<1	10	-
Simazine	µg/l	-	-	-	<0.01	1	0.075
Toluene	µg/l	-	-	-	<0.28	10	-
Tributyln	µg/l	-	-	-	<0.02	-	-
Xylene	µg/l	-	-	-	<1	10	-
m & p xylene	µg/l	-	-	-	<0.73	10	-
o xylene	µg/l	-	-	-	<0.35	10	-
total coliforms	No/100ml	0	0	0	3	0	-
faecal coliforms	No/100ml	0	0	0	0	0	-

3.4 Leachate Monitoring

Leachate samples were collected from the trial pits TP-2, 13 and 14.

3.4.1 Sampling Methodology

Leachate sampling was undertaken in TP-2 on the 23rd October 2009. Leachate sampling was undertaken in TP-13 and TP-14 on the 15th December 2009. The samples were placed in laboratory prepared containers, stored in a cooler, and sent for analyses to Euro/Fitz Scientific Laboratory.

3.4.2 Laboratory Analysis

The samples were analysed for a range of organic and inorganic parameters that included indicators of general water quality and leachate contamination. The laboratory methodologies were all ISO/CEN approved or equivalent.

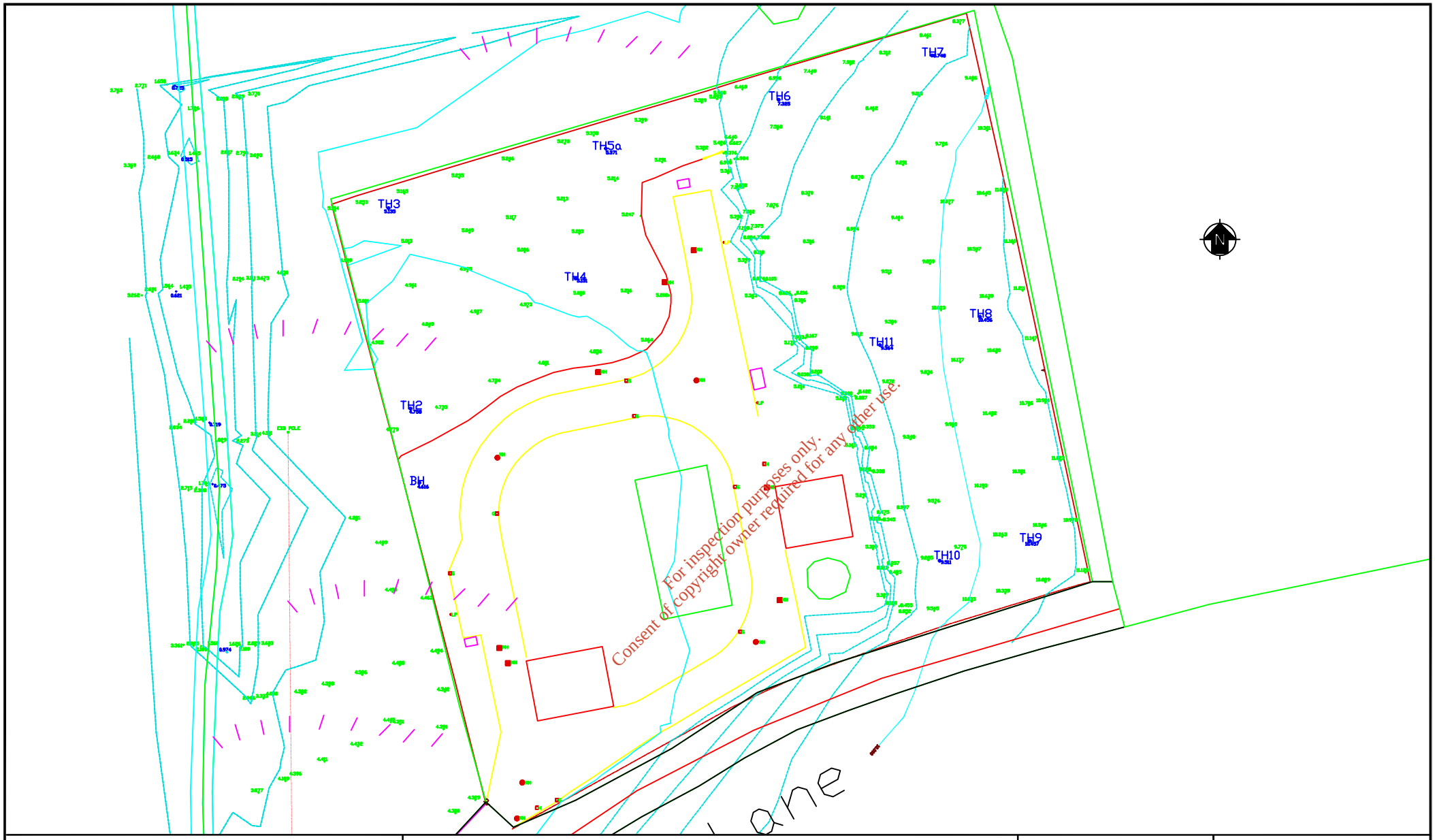
3.4.3 Laboratory Results

The full laboratory test report is in Appendix 3 and the results are summarised in Table 3.3. Included in the Table, for comparative purposes, are the ranges (weak to strong) for the individual substances typically found in leachate, which are derived from the EPA's Landfill Design Manual.

Table 3.3 Leachate Results

Sample I.D. / Sample Date	Units	TP-2	TP-13	TP-14	EPA Landfill Design Manual Range
Arsenic	µg/l	2.7	-	8.5	<1 - 6,700
Boron	µg/l	317.5	-	440.50	-
Cadmium	µg/l	<0.09	-	0.8	<10 - 80
Copper	µg/l	1.2	-	19.6	20 - 620
Mercury	µg/l	<0.03	-	<0.03	<0.1 - 0.8
Nickel	µg/l	3.5	-	13.1	<30 - 600
Lead	µg/l	1.8	-	46.4	<40 - 1,900
Zinc	µg/l	<4.6	-	78.9	<30 - 6,700
Iron	µg/l	21,820	-	45,810	1,600 - 160,000
Manganese	µg/l	2,746	-	3,046	40 - 3,590
Calcium	mg/l	230.2	-	176.90	23 - 501
Magnesium	mg/l	36.96	-	31.34	40 - 1,580
Sulphate	mg/l	<1.39	-	<1.39	<5 - 322
Chloride	mg/l	38.36	-	32.5	570 - 4,710
Fluoride	mg/l	0.4	-	0.44	-
Total Cyanide	µg/l	<5	-	<5	-
Chromium	µg/l	7.1	-	11.2	-
Phosphorous	µg/l	94	172	62	-
Potassium	mg/l	59.7	-	43.82	100 - 1,580
Sodium	mg/l	24.12	-	21.99	474 - 3,650
pH	pH units	-	7	-	6.8 - 8.2
Electrical Conductivity	µS/cm	-	710	-	5,990 - 19,300
Total Oxidised Nitrogen	mg/l	<0.03	-	<0.28	-
Ammonia	mg/l	49.31	3.86	28.5	283 -- 2,040
BOD settled	mg/l	<20	-	<2	110 - 1,900
COD	mg/l	114	29	246	622 - 8,000
Atrazine	µg/l	<0.01	-	<0.01	-
Dichloromethane	µg/l	<1	-	<1	-
Simazine	µg/l	<0.01	-	<0.01	-
TSS	mg/l	162	-	4335	-
Toluene	µg/l	<0.28	-	<0.28	-
Tributyln	µg/l	<0.3	-	<0.03	-
Xylene	µg/l	<1	-	<1	-
m & p xylene	µg/l	-	-	<0.73	-
o xylene	µg/l	-	-	<0.35	-

The parameter concentrations are in the lower end of the range of concentrations typically found in landfill leachate and are typical of a very weak aged leachate.



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com
environmental management for business

CLIENT
LOUTH COUNTY COUNCIL

TITLE
TRIAL PIT AND BOREHOLE LOCATIONS

details

FIGURE No.
3.1

SCALE

REV.

3.5 Surface Water Monitoring

Surface Water sampling was undertaken on the 22nd October 2009, 14th December 2009 by LCC and on the 12th January 2011 by AMC Environmental Ltd. Surface water sampling was carried out on the stream which flows along the eastern site boundary.

3.5.1 Sample Locations

Two samples were collected on both the 22nd October 2009 and the 12th January 2011. One samples on each occasion was collected upstream and another downstream of the site. The samples which were deemed to be upstream were taken at the outfall from the culverted section of the stream. This location is not truly upstream of the landfill but the furthest feasible upstream sampling location. One sample was collected on the 14th December 2009 downstream of the site.

3.5.2 Sampling Methodology

The sampling was carried out by full submergence of the laboratory supplied sample containers into the surface water body where possible. During submergence every effort was made to keep the container steady so as to prevent sediment disturbance. The sample was placed in laboratory prepared containers, stored in a cooler, and sent for analyses to either Jones Environmental in the UK or Euro/Fitz Scientific Laboratory in Drogheda.

3.5.3 Laboratory Analysis

The samples were analysed for a range of organic and inorganic parameters that included indicators of general water quality and leachate contamination. The laboratory methodologies were all ISO/CEN approved or equivalent and the method detection limits were all below the relevant guidance limit.

3.5.4 Laboratory Results

The laboratory test report is contained in Appendix 3 and the results are summarised in Table 3.4. The table includes, for comparative purposes, Environmental Quality Standards (EQS) published by the EPA. The EQS limits are proposed water quality standards derived from the EU Directive on Drinking Water Quality 80/778/EEC and the Directive on the Protection of Groundwater against pollution caused by certain dangerous substances 80/66/EEC.

Table 3.4 Surface Water Results

Sample I.D.	Units	Upstream 22/10/09	Downstream 22/10/09	Stream 14/12/09	Upstream 12/01/11	Downstream 12/01/11	AA-EQS*	MAC-EQS**
pH	pH Units	8.00	7.50	7.40	8.00	8.37	4.5< pH < 9.0	4.5< pH < 9.0
Electrical Conductivity	uS/cm	394	437	576	386	405	-	-
Dissolved Oxygen	mg/l	-	-	-	-	-	-	-
Antimony	mg/l	-	-	-	<0.002	<0.002		
Arsenic	mg/l	0.0002	0.0005	-	<0.0025	<0.0025	0.02	-
Boron	mg/l	0.272	0.2002	-	0.02	0.033	-	-
Cadmium	mg/l	0.0002	0.0001	-	<0.0005	<0.0005	-	-
Copper	mg/l	0.0019	0.0022	-	<0.007	<0.007	0.005	-
Lead	mg/l	0.0033	0.0012	-	0.006	0.006	-	-
Manganese	mg/l	0.0051	0.280	-	0.002	0.015	-	-
Magnesium	mg/l	1.76	2.430	-	0.0039	0.005	-	-
Mercury	mg/l	<0.00003	<0.00003	-	<0.001	<0.001	0.00005	0.00007
Nickel	mg/l	0.0013	0.001	-	<0.002	<0.002	0.02	-
Iron	mg/l	0.235	0.6532	-	0.074	0.075	-	-
Total Cyanide	mg/l	<0.05	<0.05	-	-	-	0.01	-
Chromium	mg/l	0.0013	0.0009	-	<0.0015	<0.0015	0.0006	0.032
Zinc	mg/l	0.0075	0.007	-	0.038	0.043	0.04	-
Sulphate	mg/l	11.92	12.97	-	9.04	10.93	-	-
Chloride	mg/l	13.51	15.39	-	14.9	19.6	-	-
Calcium	mg/l	48.47	53.96	-	69.3	71	-	-
Fluoride	mg/l	0.11	0.11	-	-	-	1.5	-
Phosphorus	mg/l	<0.006	0.01	0.19	0.034	0.08	0.035	-
Total Oxidised Nitrogen	mg/l	2.17	1.64	-	1.10	1.34	-	-
Total Suspended Solids	mg/l	7	<2	-	<10	<10	-	-
Total Alkalinity as CaCO3	mg/l	180	198.00	-	159	178.00	-	-
BOD	mg/l	<2	<2	<2	<1	<1	1.5	-
COD	mg/l	<5	<5	28	<7	<7	-	-
Potassium	mg/l	1.37	1.75	-	1.3	2.60	-	-
Sodium	mg/l	7.69	8.89	-	10.1	13.90	-	-
Ammonia*	mg/l	0.07	0.04	0.49	0.07	0.06	0.065	0.06
PAH	mg/l	-	-	-	-	-	-	-
VOC	mg/l	-	-	-	-	-	-	-
sVOC	mg/l	-	-	-	-	-	-	-
Pesticides	mg/l	-	-	-	-	-	-	-
Atrazine	µg/l	<0.01	<0.01	-	-	-	-	-
Dichloromethane	µg/l	<1	<1	-	-	-	-	-
Simazine	µg/l	<0.01	<0.01	-	-	-	-	-
Toluene	µg/l	<0.28	<0.28	-	-	-	-	-
Tributyln	µg/l	<0.02	<0.02	-	-	-	c-	-
Xylene	µg/l	<1	<1	-	-	-	-	-
m & p xylene	µg/l	<0.73	<0.73	-	-	-	-	-
o xylene	µg/l	<0.35	<0.35	-	-	-	-	-

*AA: Annual Average

**MAC: Maximum Allowable Concentration

On the 22nd October 2009 the level of ammonia detected in the upstream sample was greater than the EQS. The level of chromium detected in both up and downstream samples were greater than the annual average EQS but lower than the maximum allowable concentration EQS.

On the 14th December 2009 the level of ammonia detected in the sample (downstream) was greater than the EQS. The level of phosphorus was greater than the annual average EQS, there is no established maximum allowable concentration EQS for this parameter.

On the 12th January 2011 the level of ammonia detected in the upstream sample was greater than the EQS. The levels of zinc and phosphorus were greater than the annual average EQS, there is no established maximum allowable concentration EQS for these parameters.

3.6 Stream Sediment Sampling

Sediment samples were collected from the stream at upstream and downstream locations on the 12th January 2011 by AMC Environmental Ltd.

The samples were collected in laboratory supplies container and stored in cooler boxes prior to shipment to Jones Environmental Laboratory in the UK.

3.6.1 Laboratory Analysis

The samples were analysed for a range of organic and inorganic parameters that included indicators of soil quality and leachate contamination. The laboratory methodologies were all ISO/CEN approved or equivalent and the method detection limits were all below the relevant guidance limit.

3.6.2 Laboratory Results

The laboratory test report is contained in Appendix 3 and the results are summarised in Table 3.5. The tables include, for comparative purposes, values for soil quality prepared by the Environmental Protection Agency (EPA) which indicate typical background levels for a range of parameters in Irish Soils.

3.6.3 Laboratory Results

There was a slight increase in the concentration of metals between the upstream and downstream sampling points. There was however a decrease in the levels of alkalinity and ammonia between the up and downstream sampling points. All parameters were within the typical concentration for unpolluted Irish soils.

Table 3.5 Sediment Sampling Results

Sample I.D.	Units	Upstream 12/01/2011	Downstream 12/01/2011	EPA Range
pH	pH Units	7.42	7.47	-
Electrical Conductivity	uS/cm	1500	1475	-
Antimony	mg/kg	<1	<1	0.2 - 0.3
Arsenic	mg/kg	6	12.6	1.0 - 50
Boron	mg/kg	1.9	5.2	20 - 1,000
Cadmium	mg/kg	0.3	0.6	0.1 - 1
Copper	mg/kg	32	44	2 - 100
Lead	mg/kg	24	54	2 - 80
Manganese	mg/kg	416	456	-
Magnesium	mg/kg	<25	<25	1,000 - 15,000
Mercury	mg/kg	0.1	0.2	0.03 - 0.8
Nickel	mg/kg	36.8	51.9	0.5 - 100
Iron	mg/kg	26,900	39,460	10,000 - 50,000
Total Chromium	mg/kg	36.3	57.9	5 - 250
Zinc	mg/kg	118	157	10 - 200
Sulphate	mg/kg	0.062	0.34	-
Chloride	mg/kg	116	205	30 - 300*
Calcium	mg/kg	<500	<500	5,000 - 30,000
Phosphorus	mg/kg	890	866	200 - 2,000
Total Oxidised Nitrogen	mg/kg	0.07	0.13	-
Total Alkalinity as CaCO3	mg/kg	16,596	701	-
Potassium	mg/kg	<5	<5	1,000 - 30,000
Sodium	mg/kg	10	14	500 - 1,500
Ammonia*	mg/kg	12.20	3.10	-

*Chlorine range

3.7 Landfill Gas Monitoring

3.7.1 Gas Well Installation

Five landfill gas monitoring wells (BH-1 to BH-5) were installed on site between the 11th and 13th January 2011 by AMC Environmental Ltd. A landfill gas report was prepared and is included in Appendix 4. The locations of the gas wells are presented in the report in Appendix 4.

BH-1, 3 and 4 were located in the central section of the site were the waste material was thickest. BH-2 was located in the most north western corner of the site. BH-5 was located in the most south western corner of the site.

3.7.2 Landfill Gas Monitoring

Landfill gas monitoring was conducted in five landfill gas wells between February 2011 and June 2011 by AMC Environmental Ltd. The monitoring included the measurement of methane, carbon dioxide, oxygen and atmospheric pressure using a GA2000 gas analyser. The meter was calibrated before use. The detection limit is 0.1% for methane, carbon dioxide and oxygen.

Gas monitoring was also undertaken in the on site building on both the 14th and 15th December 2009. Gas was not detected in the building on either day.

The landfill gas survey results are presented in Table 3.6-3.7. The table includes guideline limits taken from the Department of the Environment (DOE) publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

3.7.3 Gas Levels Detected

Carbon dioxide was detected at levels greater than the DOE limit of 1.5% in BH-1 and 3 on all occasion and in BH-4 on all occasions bar the first. The highest level detected was 18.1% in BH-4. The lowest level detected was 4.8% in BH-4.

Methane was detected at levels greater than the DOE limit of 1% in BH-1 and 3 on all occasion and in BH-4 on all occasions except for the first monitoring period. The highest level detected was 53.8% in BH-1. The lowest level detected was 5.5% in BH-4.

The guidelines stipulate that, where carbon dioxide or methane are present in a landfill at 0.5% v/v and 1% v/v respectively, then housing should not be erected within 50 m of the landfill and private gardens should not be allowed within 10 m. There is an existing building on site. There is also a housing estate which is still being constructed and has completed houses within 50m.

The absence of landfill gas in the wells BH-2 and BH-5 would suggest that lateral movement of landfill gas to the west and towards surrounding houses is not taking place.

Table 3.6 Methane Monitoring Results 2011

	02-Feb	18-Feb	04-Mar	23-Mar	15-Apr	03-Jun	DOE Limit %
CARLIBH1	30.6	53.8	40	25.4	34.4	25.9	1
CARLIBH2	0	0	0	0	0	0	1
CARLIBH3	14.4	27	28.6	20.2	18.7	17.6	1
CARLIBH4	0.7	6.2	14.5	5.5	11.3	38.8	1
CARLIBH5	0	0	0	0	0	0	1

Table 3.7 Carbon Dioxide Monitoring Results 2011

	02-Feb	18-Feb	04-Mar	23-Mar	15-Apr	03-Jun	DOE Limit %
CARLIBH1	15.1	17	13.7	13.9	16.4	15.5	1.5
CARLIBH2	0	0.8	0.6	0.9	0.1	0.9	1.5
CARLIBH3	7.6	13.4	13.8	10.3	10	9.8	1.5
CARLIBH4	0.7	14.9	4.8	15.4	12.4	18.1	1.5
CARLIBH5	0.5	1.5	1.1	0.9	1.3	1.3	1.5

3.8 Geotechnical Testing

Seven samples were collected for Geotechnical testing. Two samples were collected from the clay capping material used on site and five were collected from the natural subsoils underlying the fill material.

The samples were subjected to permeability and strength tests. The analysis was carried out by Euro Environmental Laboratory. The full laboratory report is included in Appendix 3. The results are summarised in Table 3.8. The permeability of the overlying capping layer ranged from 1.2 x 10^{-9} to 3.2 x 10^{-9}. The permeability of the underlying natural subsoils ranged from 1.9 x 10^{-9} to 4.0 x 10^{-10}.

The permeability test results indicate the presence of very low permeability subsoil which greatly inhibits vertical migration of rainfall and leachate and indicates that surface water is the preferential pathway leachate migration.

Shear strength analysis was carried out in the capping material in TP-3 and TP-7 and the natural subsoils in TP-7. The full laboratory report is included in Appendix 3. The results are summarised in Table 3.7. The shear strength for the capping layer ranged from 03.8kPa to 127kPa. The shear strength of the natural subsoils samples was 339kPa.

Table 3.8 Geotechnical Analysis Summary

Trial Pit Number	Sample Depth (m)	Permeability	Shear Strength (kPa)
1	2.6	4×10^{-10}	
2	4	2.8×10^{-10}	
3	1.65	3.2×10^{-09}	127
7	1	1.2×10^{-09}	103.8
7	4	3.8×10^{-09}	339
10	2.8	1.9×10^{-09}	
11	4.2	3.8×10^{-09}	

3.9 Geophysical Survey

A geophysical survey was completed in December 2009. The geophysical survey comprised EM31 ground conductivity mapping, 2D resistivity profiling and seismic refraction profiling. The full geophysical report is presented in Appendix 5

The geophysical data indicated 0-4.3m soft to firm or loose to medium dense landfill waste material across approximately 0.92Ha of the site with portions of the lands to the east and west in which it was previously assumed that waste was present comprising natural ground. The survey also showed that there was no waste present beneath the wastewater treatment plant footprint. The survey indicates an average waste thickness of 2.5-3.0m.

Moderately low resistivity material (33-90 Ohm) underlying the waste has been interpreted as possible leachate. The geophysical survey identified potential leachate zones beneath the waste material as well as zones of leachate extending to the north and west of the site.

The survey indicted the potential presence of estuarine deposits beneath the waste material.

Higher resistivity material underlying the waste, as well as to the north-east, has been interpreted generally as clayey sand/gravel.

3.10 Migration Pathways for Leachate and Landfill Gas Migration

3.10.1 Landfill Gas

The landfill gases methane and carbon dioxide were detected at elevated levels in three of the on site gas wells. Landfill gases has never been detected in the on site buildings. OCM understand that the buildings have been fitted with gas proof membranes. Prior to construction waste beneath and immediately surrounding the buildings were excavated out and placed on the northern part of the site. Granular fill was placed to establish formation level around the buildings. It is likely that any landfill gas migration toward the buildings is venting to atmosphere in the granular fill surrounding the buildings. While a potential pathway from the landfill to the on site buildings exists this has for the most part been mitigated if landfill gas proof membranes have been incorporated in the construction process.

There is a housing development within 50m of the western site boundary. The presence of the stream on the western site boundary may act as a natural cut off inhibiting lateral migration of gas to the west towards houses. Landfill gases were not detected in BH-2 and BH-5 which are on the north western and south western site boundary. This would indicate that lateral migration of gas is not occurring in these directions.

3.10.2 Surface Water and Sediment

There is a pathway from the landfill to a receiving surface water course (the unnamed stream). Based on the surface water monitoring data there is not a significant deterioration in the surface water quality between the upstream and downstream monitoring points on the stream.

Sediment sampling undertaken in the stream shows a small increase in metals between the upstream and downstream locations however the general quality of the sediment is within the typical range for unpolluted Irish soils.

3.10.3 Groundwater

The site is underlain by a locally important gravel aquifer. There is a layer of blue grey low permeability silt/clay overlying the gravels. The clay ranges in thickness from 2.1m to 0.5m. If leachate percolated through the clay layer the underlying gravel aquifer would allow migration of leachate vertically and laterally away from the landfill. The natural gradient within the aquifer would be to the north and north east away from the site towards Carlingford Lough. Monitoring indicates that the leachate is an aged and very dilute. Therefore the risk posed to groundwater is expected to be low.

There is a groundwater abstraction well located in the gravel aquifer located approximately 55m to the south west and up hydraulic gradient of the site. The well is pumping up to 1,200m^3/day of groundwater. This pumping rate may result in groundwater flowing beneath the site in the sand and gravels being pulled toward the abstraction well. The landfill is located within the source protection zone for the well. There is therefore potential for migration of leachate from the landfill to the well. Groundwater monitoring in the well has however not detected any water quality impacts. This may indicate that the estuarine clays beneath the site are an effective barrier to vertical leachate migration and that leachate migration is generally toward the surface water system because of the presence of estuarine clay above the gravel. Because the leachate is very weak the potential impacts on water quality are expected to be very low.

4. BIOLOGICAL ASSESSMENT OF SURFACE WATER AND APPROPRIATE ASSESSMENT SCREENING

4.1 Introduction

As part of the monitoring of water quality in the vicinity of the former landfill at Carlingford, Co. Louth, Conservation Services, Ecological & Environmental Consultants (CSE&E) were commissioned by Louth County Council to carry out a biological sampling and water quality assessment in accordance with EPA Q-rating methodology at two locations on the stream adjacent to the former landfill. The assessment was carried out in April 2010. The full Biological Assessment report is presented in Appendix 6 and summaries here.

Biological and water quality sampling was carried out at two sites on the stream. Site 1 was located a short distance downstream of the upstream limit of the former landfill. A site immediately upstream of the landfill was not possible as the stream is culverted upstream of the former landfill. Site 2 was directly downstream of the landfill.

4.2 Habitat Assessment

A habitat assessment was carried out at each of the locations selected for invertebrate/water quality assessment. These sites were assessed in terms of:

- Stream width and depth
- Substrate type, listing substrate fractions in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.
- Flow type, listing percentage of riffle, glide and pool in the sampling area
- Instream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site
- Dominant bankside vegetation, listing the main species overhanging the stream
- Estimated summer cover by bankside vegetation, giving percentage shade of the sampling site
- Rating of the site as habitat for trout adult, nursery and spawning on a scale of Poor/Fair/Good/Very Good/Excellent. This rating assesses the physical suitability of the habitat; the presence/absence/density of salmonids at the site will also depend on present and historical water quality and accessibility of the site to fish.

4.3 Invertebrate Sampling and Water Quality Assessment

A sweep net invertebrate sample was taken at each site as the deep mud substrate rendered the site unsuitable for the standard kick sampling method employed by EPA. Each sample was retained in a large plastic bag at the sampling site. Sample processing and preservation was carried out under laboratory conditions within 24 hours of sampling. Mud was removed from each sample by sieving under running water through a 500µ sieve. Sieved samples were then live sorted for 30 minutes in a white plastic sorting tray under a bench lamp (ISO 5667-3:1994) and if necessary using a magnifying lens. Macroinvertebrates were stored in 70% alcohol. Preserved invertebrates were identified to the level required for the EPA Q-rating method (Clabby *et al*, 2006) using high-power and low-power binocular microscopes when necessary. The preserved samples were archived for future examination or verification. Based on the relative abundance of indicator species, a biotic index (Q-rating) was determined for each site in accordance with the biological assessment procedure used by the Environmental Protection Agency (Clabby *et al* 2006) and more detailed unpublished methodology (McGarrigle, Clabby and Lucey pers. comm.).

Biotic Index	**Water Framework Directive Ecological Status**	**Quality Status**
Q5	High	Unpolluted Waters
Q4-5	High	
Q4	Good	
Q3-4	Moderate	Slightly Polluted Waters
Q3	Poor	Moderately Polluted Waters
Q2-3	Poor	
Q2	Bad	Seriously Polluted Waters
Q1-2	Bad	
Q1	Bad	

The scheme mainly reflects the effects of organic pollution (i.e. deoxygenation and eutrophication) but where a toxic effect is apparent or suspected the suffix ‘0’ is added to the biotic index (e.g. Q1/0, 2/0 or 3/0). An asterisk after a Q value indicates something worthy of attention, typically heavy siltation of the substratum.

4.4 Results

At Site 1 the macroinvertebrate fauna recorded at the site merit a Q-rating of Q3 indicating poor ecological status and moderately polluted conditions.

At Site 2 the macroinvertebrate fauna recorded at the site merit a tentative Q-rating of Q3/0 indicating poor ecological status and moderate levels of organic pollution with a suspected additional toxic effect on invertebrates.

On the basis of similar substrate conditions it would be expected that, in the absence of any impact between the upstream and downstream sites, the macroinvertebrate faunal communities would be broadly similar. The faunal communities at the two sites are in reality significantly different. Whereas gastropods (*Lymnaea peregra*) and crustaceans (*Gammarus duebeni)* are numerous at Site 1, they are virtually absent at Site 2 (a single *Lymnaea peregra* was recorded at the site). Furthermore, for a site with moderate levels of organic enrichment, the invertebrate abundance at Site 2 is abnormally low, for all groups except Chironomidae (excl. *Chironomus*) which frequently dominate the invertebrate community at sites which are suffering or are recovering from a significant perturbation.

Johnson, Wiederholm & Rosenberg (1993) state: "*Reduced total abundance and species richness and changes in macroinvertebrate dominance often occur in aquatic systems polluted by heavy metals. …Generally, insects appear to be less sensitive than gastropods and crustaceans to metal exposure.*" Johnson, Wiederholm & Rosenberg (1993) also state: "*Crustacea as well as Mollusca (except for Sphaeriidae) are sensitive to low pH.*"

CSE & E conclude that the results of the survey are suggestive of, but do not prove, an impact on the stream from the landfill. The biological data recorded downstream of the former landfill would be characteristic of a impact such as low level heavy metals pollution or a pollutant capable of reducing stream pH.

4.5 Appropriate Assessment Screening

An Appropriate Assessment is required under Article 6 of the Habitats Directive (92/43/EEC), in instances where a plan or project may give rise to significant effects on a Natura 2000 site. Carlingford Shore Special Area of Conservation (SAC) and the Carlingford Lough Special Protection Area (SPA) are located approximately 500m to the north east of the site (Figure 2.6). The Carlingford Mountain SAC is located approximately 1km to the west of the site.

The Risk Assessment has identified the site as a High Risk site because of the Leachate to Surface Water Pathway. This pathway has the potential to link the site to ecologically sensitive sites downstream.

Natura 2000 sites are those identified as sites of European Community importance and designated as such under the EU Habitats Directive (92/43/EC) (Special Area of Conservation) or the Birds Directive (Special Protection Areas). The closest Natura 2000 sites are the Carlingford Shore Special Area of Conservation (SAC) and the Carlingford Lough Special Protection Area (SPA). They are located approximately 500m to the north east of the site. These are located downgradient of the site.

The Habitats Directive, which is implemented under the European Communities Birds and Natural Habitats) Regulations 2011 (S.I. No 477 of 2011) requires an "appropriate assessment" of the potential impacts any works may have on the conservation objectives of any Natura 2000 site. Article 6(3) of the Directive stipulates that *any plan or project not directly connected with or necessary to the management of a Natura 2000 site, but likely to have a significant effect thereon…shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives.*

Guidance documents issued by Department of Environment, Heritage and Local Government and the National Parks and Wildlife Services recommend that the assessment be completed in a series of Stages, which comprise:

Stage 1: Screening

The purpose of this Stage is to determine, on the basis of a preliminary assessment and objective criteria, whether a plan or project, alone and in combination with other plans or projects, could have significant effects on a Natura 2000 site in view of the site's conservation objectives.

Stage 2: Appropriate Assessment

This Stage is required if the Stage 1 Screening exercise identifies that the project is likely to have a significant impacts on a Natura 2000 site.

Stage 3: Assessment of Alternative Solutions.

If Stage 2 determines that the project will have an adverse impact upon the integrity of a Natura 2000 site, despite the implementation of mitigation measures, it must be objectively concluded that no alternative solutions exist before the plan can proceed.

Stage 4: Compensatory Measures:

Where no alternative solutions are feasible and where adverse impacts remain but imperative reasons of overriding public interest require the implementation of a project an assessment of compensatory measures that will effectively offset the damage to the Natura site 2000 is required.

Stage 1 Screening Methodology

The Stage 1 Screening was conducted in accordance with the guidance presented in the "Assessment of Plans and Projects significantly affecting Natura 2000 sites, Methodological Guidance on the provisions of Articles 6(3) and 6(4) of the Habitats Directive 92/43/EEC" (2001); The Department of Environment, Heritage and Local Government (2009, revised February 2010) Appropriate Assessment of Plans and Projects in Ireland and the National Parks and Wildlife Services (2010) Circular NPW 1/10 & PSSP 2/10 Appropriate Assessment under Article 6 of the Habitats Directive: Guidance for Planning Authorities.

A list of downstream designated Natura 2000 sites (SAC and SPA) within 1 km of the site is given in Table 2.1.

Table 2.1 Designated Sites within 1km of the Waste Disposal Area**s**

Site	**Code**	**Distance**
SAC		
Carlingford Shore Special Area of Conservation	002306	500m north
Carlingford Lough Special Protection Area	004078	500m north

SACs and SPAs are selected for the conservation and protection of habitats listed on Annex I and species (other than birds) listed on Annex II of the Habitats Directive, and their habitats. The habitats on Annex I require special conservation measures. SPAs are selected for the conservation and protection of bird species listed on Annex I of the Birds Directive and regularly occurring migratory species, and their habitats, particularly wetlands.

4.5.1 Carlingford Shore Special Area of Conservation

The Carlingford Shore Special Area of Conservation is located 500m to the north of the site. The Carlingford Shore Special Area of Conservation (002306) was selected for perennial vegetation of stony banks and drift lines, both habitats listed on Annex I of the E.U. Habitats Directive.

The stony banks or shingle found along much of the site vary in width from less than a meter to approximately 50 m south of Ballagan Point. The best examples are found in this area. The perennial vegetation of the upper beach of these shingle banks is widely ranging, well developed and often stable. In places lichens encrust the stones farther back from the sea. Typical species present throughout the site include Oraches (Atriplex spp.), Sea Beet (Beta vulgaris), Wild Carrot (Daucus carota), Red Fescue(Festuca rubra), Sea-milkwort (Glaux maritima), Lyme-grass (Leymus arenarius) and Wild Radish (Raphanus raphanistrum). This grades landward into lowland dry grassland mainly though there are patches of wet grassland.

-

4.5.2 Carlingford Lough Special Protection Area

The Carlingford Lough Special Protection Area is located 500m to the north of the site. The Carlingford Shore Special Area of Conservation (004078) was selected as the site supports part of a nationally important population of wintering Cormorant (233 average maximum, 1995/96-1999/00). A range of other waterfowl species occurs, notably Brent Goose (175), Oystercatcher (172), Dunlin (267), Bar-tailed Godwit (25), Redshank (35) and Turnstone (19). The intertidal flats provide feeding areas for the wintering birds.

The Carlingford Lough SPA and Shore SAC are located c.500 downstream of the site. The surface water drainage from the site enters a stream along the western boundary and which flows to the Lough.

4.6 Conclusions

OCM consider that based on the chemical analysis carried out on the surface water and sediment samples in the stream that the site is not significantly impacting on the stream.

However, the ecological assessment concluded that the biological data recorded downstream of the former landfill would be characteristic of a impact such as low level heavy metals pollution or a pollutant capable of reducing stream pH.

While dilution downstream is likely to be substantial, particularly when the stream reaches Carlingford Lough a review of the data contained in this Tier 2 Report should be undertaken by a suitably qualified ecological consultant to establish if the site poses a risk to the SPA and SAC in Carlingford Lough.

5. REVISION OF TIER 1 RISK ASSESSMENT & CONCEPTUAL SITE MODEL

5.1 Revised Conceptual Site Model

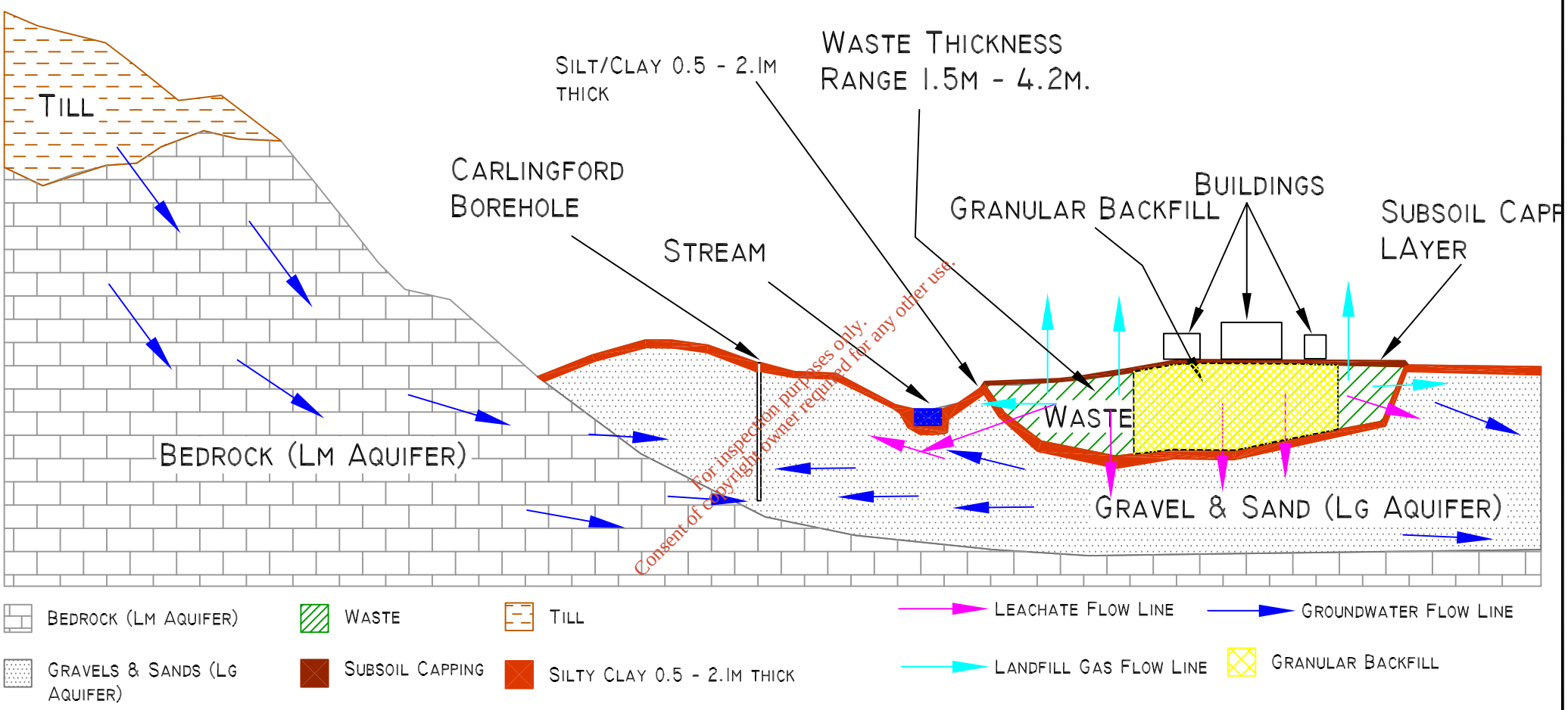
The revised Conceptual Site Model is based on the findings of the Tier 2 and is presented on Figure 5.1. There is a maximum of 4.2m of waste material which is underlain by a very low permeability, stiff grey clay (0.5-2.5m). The waste footprint is approximately 0.92Ha. The clay is underlain by clayey sands and gravels which are part of a locally important gravel aquifer (Lg).

There is limited potential for incident rainfall to percolate through the capping layer, the waste and the underlying silt/clay layer into the underlying aquifer. Because of the presence of low permeability clay beneath the waste leachate is expected to migrate preferentially toward the stream along western site boundary. Leachate analysis indicates that it is an aged and very weak leachate. The impact on groundwater water quality is therefore expected to be low. Monitoring of the public supply well located 55m to the southwest and up hydraulic gradient of the site supports this assumption. A weak leachate may be discharging into the stream which discharges into Carlingford Lough approximately 700m downstream to the north.

Surface water and sediment sampling has not identified any significant impact in the unnamed stream but some low level biological impacts were identified in a 2009 biological survey. Given the potential for significant dilution downstream biological impacts are likely to be limited.

The geophysical survey indicates the potential presence of leachate beneath the waste material as well as extending to the north and west away from the site.

Elevated levels of carbon dioxide and methane were detected in the landfill gas monitoring wells on site. Gas was not detected in the on site buildings. There remains however the potential for the migration of landfill gas into the on site buildings. Where waste is present it can vent freely to atmosphere this is the preferential pathway but some risk remains.



O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com

CLIENT LOUTH COUNTY COUNCIL

TITLE CONCEPTUAL SITE MODEL

details

FIGURE No. 5.1

SCALE

REV.

5.2 Revised Risk Assessment

The original High Risk Status was based on an over estimate of the landfill footprint prior to the development of the wastewater treatment plant. The revised risk scores are presented below. The risk scores for Source reduces from 7 to 5 for 1a and 1b and score on Table 2a changed from 3 to 2 as the aquifer vulnerability was originally believed to be extreme.

Table 1a LEACHATE: Source/hazard Scoring Matrix			
Waste Type	Waste Footprint (ha)		
	≤1ha	>1≤5ha	>5ha
C&D	0.5	1	1.5
Municipal	5	7	10
Industrial	5	7	10
Pre 1977 sites	1	2	3

1a =	**5**

Table 1b LANDFILL GAS: Source/hazard Scoring Matrix			
Waste Type	Waste Footprint (ha)		
	≤1ha	>1≤5ha	>5ha
C&D	0.5	0.75	1
Municipal	5	7	10
Industrial	3	5	7
Pre 1977 sites	0.5	0.75	1

1b=	**5**

Table 2a LEACHATE MIGRATION: Pathways	
Groundwater Vulnerability (Vertical Pathway)	Points
Extreme Vulnerability	3
High Vulnerability	2
Moderate Vulnerability	1
Low Vulnerability	0.5
High – Low Vulnerability	2

2a=	**2**

Table 2b LEACHATE MIGRATION: Pathways	
Groundwater Flow Regime (Horizontal Pathway)	Points
Karstified Groundwater Bodies (Rk)	5
Productive Fissured Bedrock Groundwater Bodies (Rf & Lm)	3
Gravel Groundwater Bodies (Rg & Lg)	2
Poorly Productive Bedrock Groundwater Bodies (Ll, Pl, Pu)	1

2b =	**3**

Table 2cLEACHATE MIGRATION: Pathways	
Surface Water Drainage (Surface Water Pathway)	Points
Is there direct connection between drainage ditches associated with the waste body and adjacent surface water body? Yes	2
If no direct connection.	0

2c =	**2**

Table 2d LANDFILL GAS: Pathways (assuming receptor within 250m of source)	
Landfill Gas Lateral Migration Potential	Points
Sand and Gravel, Made ground, urban, karst	3
Bedrock	2
All other Tills (including limestone, sandstone etc – moderate permeability)	1.5
All Namurian or Irish Sea Tills (low permeability)	1
Clay, Alluvium, Peat	1

*No receptor within 250m

2d =	**3**

Table 2e LANDFILL GAS: Pathways (assuming receptor above source)	
Landfill Gas Lateral Migration Potential	Points
Sand and Gravel, Made ground, urban, karst	5
Bedrock	3
All other Tills (including limestone, sandstone etc – moderate permeability)	2
All Namurian or Irish Sea Tills (low permeability)	1
Clay, Alluvium, Peat	1

*No receptor above waste body

2e =	**5**

Table 3a LEACHATE MIGRATION: Receptors	
Human Presence (presence of a house indicates potential private wells)	Points
On or within 50m of the waste body	3
Greater than 50m but less than 250m	2
Greater than 250m but less than 1km	1
Greater than 1km of the waste body	0

3a =	3

Table 3b LEACHATE MIGRATION: Receptors	
Protected Areas (SWDTE & GWDTE)	Points
Within 50m of the waste body	3
Greater than 50m but less than250m of the waste body	2
Greater than 250m but less than 1km of the waste body	1
Greater than 1km of the waste body	0
Undesignated sites within 50m of the waste body	1
Undesignated sites greater than 50m but less than250m of the waste body	0.5
Undesignated sites greater than 250m of the waste body	0

3b =	1

Table 3c LEACHATE MIGRATION: Receptors	
Aquifer Category (resource potential)	Points
Regionally Important Aquifers (Rk, Rf, Rg)	5
Locally Important Aquifers (El, Lm, Lg)	3
Poor Aquifer (Pl, Pu)	1

3c =	3

Table 3d LEACHATE MIGRATION: Receptors	
Public Water Supplies (other than private wells)	Points
Within 100m of the site boundary	7
Greater than 100m but less than 300m or within the in inner SPA for GW supplies	5
Greater than 300m but less than 1km or within outer SPA for GW supplies	3
Greater than 1km (karst aquifer)	3
Greater than 1km (no karst)	0

3d =	7

Table 3e LEACHATE MIGRATION: Receptors	
Surface Water Bodies	Points
Within 50 of the site boundary	3
Greater than 50m but les than 250m of the site boundary	2
Greater than 250m but less than 1km	1
Greater than 1km	0

3e =	3

Table 3f LANDFILL GAS: Receptors	
Human Presence	Points
On site or within 50m of site boundary	5
Greater than 50 but less than 150m of site	3
Greater than 150m but less than 250m of the site	1
Greater than 250m of the site	0.5

3f =	5

Risk Equation	SPR Values	Maximum Score	Linkages	Normalised Scores
SPR 1 = 1a x (2a + 2b + 2c) x 3e	147	300	Leachate →Surface Water	49.00%
SPR 2 = 1a x (2a + 2b + 2c) x 3b	49	300	Leachate →SWDTE	16.33%
SPR 3 = 1a x (2a + 2b) x 3a	105	240	Leachate → human presence	43.75%
SPR 4 = 1a x (2a + 2b) x 3b	35	240	Leachate → GWDTE	14.58%
SPR 5 = 1a x (2a + 2b) x 3c	105	400	Leachate → aquifer	26.25%
SPR 6 = 1a x (2a + 2b) x 3d	245	560	Leachate → surface water	43.75%
SPR 7 = 1a x (2a + 2b) x 3e	105	240	Leachate → SWDTE	43.75%
SPR 8 = 1a x 2c x 3e	42	60	Leachate → surface water	50.00%
SPR 9 = 1a x 2c x 3b	14	60	Leachate → SWDTE	23.33%
SPR 10 = 1b x 2d x 3f	105	150	Landfill Gas → human presence	50.00%

SPR 11 = 1b x 2e x 3f	175	250	Landfill Gas → human presence	50.00%

Risk Classification	Score Range
High Risk (Class A)	**Greater than or equal to 70% for any individual SPR linkage**
Moderate Risk (Class B)	**Between 40% and 70% for any individual SPR linkage**
Low Risk (Class C)	**Less than or equal to 40% for any individual SPR linkage**

Overall Score	**50%**
Overall Risk	**Moderate Risk (Class B)**

Note: The table below represents the Tier 2 Risk rating for this site. SPR1 to 9 represent the leachate risk scores. SPR10 & 11 represent Landfill Gas Risk. The migration pathways are colour coded as follows:

Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical

Calculator		SPR Values	Maximum Score	Normalised Score
SPR1	1a x (2a + 2b + 2c) x 3e	147	300	49.00%
SPR2	1a x (2a + 2b + 2c) x 3b	49	300	16.33%
SPR3	1a x (2a + 2b) x 3a	105	240	43.75%
SPR4	1a x (2a + 2b) x 3b	35	240	14.58%
SPR5	1a x (2a + 2b) x 3c	105	400	26.25%
SPR6	1a x (2a + 2b) x 3d	245	560	43.75%
SPR7	1a x (2a + 2b) x 3e	105	240	43.75%
SPR8	1a x 2c x 3e	42	60	50.00%
SPR9	1a x 2c x 3b	14	60	23.33%
SPR10	1b x 2d x 3f	105	150	50.00%
SPR11	1b x 2e x 3f	175	250	50.00%
Overall Risk Score		245		**50%**
				A

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	**Greater than 70 for any individual SPR linkage**
Moderate Risk (Class B)	**40-70 for any individual SPR linkage**
Lowest Risk (Class C)	**Less than 40 for any individual SPR linkage**

Risk Classification	**Moderate**

6. CONCLUSIONS AND RECOMENDAITONS

6.1 Conclusions

The Detailed Site Investigation indicates that the site is Class B Moderate Risk based on the revised waste footprint, the potential risk posed to surface water and groundwater from leachate migration. Landfill gas risk is also Moderate due to the presence of the onsite buildings and limited potential for off-site landfill gas migration.

An aged, weak, leachate was detected in the waste and this may be entering the surface water system down stream of the landfill.

Based on the chemical analysis carried out on the surface water and sediment samples the site is not significantly impacting on the stream. This may be due to the dilution in the watercourse and the presence of an aged and weak leachate beneath the site.

However, the ecological assessment concluded that the biological data recorded downstream of the former landfill would be characteristic of a impact such as low level heavy metals pollution or a pollutant capable of reducing stream pH.

While dilution downstream is likely to be substantial, particularly when the stream reaches Carlingford Lough a review of the data contained in this Tier 2 Report should be undertaken by a suitably qualified ecological consultant to establish if the site poses a risk to the SPA and SAC in Carlingford Lough.

Elevated levels of landfill gas were detected in the on site gas monitoring wells in the central area of the site. The levels detected exceeded the DOE limits for Carbon Dioxide and Methane. Gas was not detected in the wells on the north and south western site boundary.

Elevated levels of iron, manganese and coliforms were detected in the on site well. These may be a result of a weak leachate from the landfill. No impact was detected in the off site Carlingford groundwater water supply borehole.

The waste characterisation analysis of the waste samples collected from the trial pits shows that the waste material can be classified as inert.

6.2 Recommendations

6.2.1 Surface Water

Surface water sampling should be carried out and scheduled to coincide with low flow conditions which typically occur in August/September. The samples should be analysed for the parameters specified in Table C.2 of the EPA landfill Design Manual 2003 (2nd Edition).

6.2.2 Groundwater Monitoring

Groundwater monitoring of the Carlingford supply well will be ongoing and should be reviewed to establish that water quality is not impacted as a result of leachate migration from the site.

6.2.3 Landfill Gas

Landfill gas ventilation trenches should be installed in the northern portion of the site where elevated readings have been detected and from where waste has been moved from beneath the on-site buildings. The trenches should comprise vertical ventilation pipes installed in trenches backfilled with granular fill. Where possible, vertical ventilation pipe work should extend to the full depth of the waste. The trenches should be c1m wide and at least 2m deep and should be located to ensure maximum ventilation of landfill gas in the northern portion of the site. The vertical ventilation pipes should extend above ground and be fitted with a cowel to prevent the pipes from being blocked by debris.

6.2.4 Leachate Risk

If future dry weather surface water monitoring indicates an impact in the unnamed stream, measures will be required as part of a Tier III remedial works programme to control leachate release. This may include the placement of low permeability clay over the fill area in the northern portion of the site to reduce rainfall recharge to the fill area and monitoring to assess the effectiveness of such measures.

6.2.5 Development Risk

Any future development of the landfill area must take into consideration the potential risk posed by the presence of landfill gas. It is likely that either waste would have to be removed form beneath the footprint of any future development area or that an effective physical barrier layer would have to be placed between the waste mass and the proposed development.

6.2.6 Appropriate Assessment

The ecological assessment undertaken in 2010 concluded that a limited biological impact may have occurred downstream of the landfill.

While dilution downstream is likely to be substantial, particularly when the stream reaches Carlingford Lough a review of the data contained in this Tier 2 Report should be undertaken by a suitably qualified ecological consultant to establish if the site poses a risk to the SPA and SAC in Carlingford Lough. If the ecological review considers that the site poses a potential risk to the SPA and/or SAC a Stage 2 Appropriate Assessment should be undertaken by a suitably qualified Ecological Consultant.

7. GENERIC QUANTITATIVE RISK ASSESSMENT

Risk assessment is a scientific mechanism that allows the various hazards, pathways and receptors present at a site to be evaluated. It uses a systematic and progressive approach to identify the risks with the aim of establishing a pollutant linkage from a source (S) via a pathway (P) to a receptor (R). If a pathway does not exist there is no risk.

The CSM completed in the Tier 1 Assessment identified leachate and landfill gas as the sources; surface water, groundwater, air and soil as potential pathways; and surface water courses, the bedrock aquifer and humans as the potential receptors. The highest potential linkage scores were for SPR 8 (70%), SPR10 (70%) and SPR11 (70%) and the overall site classification was 'High Risk'.

The objective of the Tier 2 assessment was to establish if the SPR linkages identified in the Tier 1 actually existed. The Assessment identified that the while all of the linkages existed the source area was lower than originally assumed and the risk scores reduced accordingly for SPR 8 (50%), SPR10 (50%) and SPR11 (50%) and the overall site classification was 'Moderate Risk'.

7.1 Potential Sources

There is a maximum of 4.2m of waste material which is underlain by a very low permeability, stiff grey clay (0.5-2.5m). The waste footprint is approximately 0.92Ha. The clay is underlain by clayey sands and gravels which are part of a locally important gravel aquifer (Lg).

7.1.1 Waste Body

The Tier II site investigations identified the presence of a waste body comprising approximately 0.92Ha with an average thickness of 2.5 – 3m. This equates to approximately 52,760,000m3 of waste intermingled with sand and clay. The waste density is estimated to be 0.4 which equates to approximately 1,104,000 tonnes of waste. The lateral and vertical extent of the waste was established. A naturally occurring low permeability CLAY layer was identified beneath the waste in the tirla pits and geophysical site survey The base CLAY layer appears to be forming an effective barrier between the landfill and the underlying sand and gravel aquifer.

The waste generally comprised aged domestic waste including papers, plastics, glass, wiring, steel fragments, concrete fragments and timber. The waste was incorporated in a sandy gravely clay matrix. No layers or pockets of significantly contaminated material was encountered. There was no evidence of staining or odours consistent with the presence of such material identified during field screening activities. Based on observations of the waste during the site investigations it is reasonable to assume that the waste could be considered to be typical non-hazardous municipal solid waste. Waste Acceptance classification testing indicates that the waste is inert.

7.1.2 Subsoils

The CSM was revised following the Tier II Investigations. The trial pits showed a low permeability clay layer under the landfill which is most likely alluvium associated with the presence of the stream along the western site boundary. This low permeability clay layer appears based on observations from the trial pitting programme to be naturally occurring and extends beneath the landfill to the west toward the stream and to the north toward the estuary. There is limited potential for incident rainfall to percolate through the capping layer, the waste and the underlying silt/clay layer into the underlying aquifer. Because of the presence of low permeability clay beneath the waste leachate is expected to migrate preferentially toward the stream along western site boundary.

7.1.3 Leachate

Three leachate samples were collected from trial pits (TP-2, 13 and 14). The leachate was tested for the parameters specified in Table C2 of the EPA Landfill Monitoring Manual 2003 for the sample from TP-7 and for a minor suite of parameters for all other locations (as recommended in the EPA 2009 Matrix Guidance which is included in Appendix 2). The results were presented in Table 3.2 above.

Leachate quality is considered to be in late stages of Stage IV or in Stage V (Aerobic Stage) of the biodegradation process.

7.1.4 Landfill Gas

Landfill gas monitoring was conducted in five landfill gas wells between February 2011 and June 2011 by AMC Environmental Ltd. The monitoring included the measurement of methane, carbon dioxide, oxygen and atmospheric pressure using a GA2000 gas analyser.

Gas monitoring was also undertaken in the on-site building on both the 14th and 15th December 2009. Gas was not detected in the buildings on either day.

The landfill gas survey results are presented in Table 3.6-3.7. The table includes guideline limits taken from the Department of the Environment (DOE) publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

Gas Levels Detected

Carbon dioxide was detected at levels greater than the DOE limit of 1.5% in BH-1 and 3 on all occasion and in BH-4 on all occasions bar the first. The highest level detected was 18.1% in BH-4. The lowest level detected was 4.8% in BH-4.

Methane was detected at levels greater than the DOE limit of 1% in BH-1 and 3 on all occasion and in BH-4 on all occasions except for the first monitoring period. The highest level detected was 53.8% in BH-1. The lowest level detected was 5.5% in BH-4.

The guidelines stipulate that, where carbon dioxide or methane are present in a landfill at 0.5% v/v and 1% v/v respectively, then housing should not be erected within 50 m of the landfill and private gardens should not be allowed within 10 m. There is an existing building on site. There is also a housing estate which is still being constructed and has completed houses within 50m.

The absence of landfill gas in the wells BH-2 and BH-5 would suggest that lateral movement of landfill gas to the west and towards surrounding houses is not taking place.

7.2 Potential Pathways

To establish the pollutant linkage, a pathway or pathways to the receptor must be identified. This is the route by which a hazard can move toward the receptor. The pathways may allow the passage of a hazard in any of its three basic phases or in a combination, i.e. as a liquid as a solid or as a gas. Potential pathways for the site are shown in Table 7.1.

Potential Pathway	Route
Surface Water	Leachate migration from the landfill discharging into the stream to the west of the site which discharges to Clrlingford Lough c.500m north
Groundwater	Contaminant migration to the water table through the base of the landfill into the subsoil and underlying sand and gravel aquifer.
Air/Soil	Landfill gas migration to buildings along subsurface or surface pathway.

Table 7.1 Potential Pathways

7.3 Potential Receptors

Potential receptors are identified in Table 72.

Potential Receptor	Type
Surface Water	The Stream to the west and Carlingford Lough SAC/SPA 0.5km downstream
Groundwater	Sand and Gravel Aquifer beneath the site
Human Beings/Animals	Private wells and public supply downstream in the catchment. Animal water supply from stream, inhalation of gases or gas explosion risk in confined spaces

Table 7.2 Potential Receptors

7.4 Pollution Linkages

Potential hazards, pathways, and receptors have been identified at the site. For a risk to pose a significant threat to a receptor a linkage via a pathway must be established.

7.1.1 7.4.1 Surface Water

Leachate generated in the waste mass has the potential to migrate laterally from the landfill into the Stream. Monitoring of surface water quality is discussed in Section 3.5. Monitoring was undertaken up and downstream of the landfill on two occasions. SW-1 is upstream and SW-2 is downstream. The results have been compared to the EPA Environmental Quality Standard limits. Based on the surface water monitoring data there is not a significant deterioration in the surface water quality between the upstream and downstream monitoring points on the stream. Ammonia levels above the EQS were detected in the stream upstream of the landfill. The source of ammonia is most likely agricultural run-off in the catchment up stream of the site.

7.1.2 7.4.2 Stream Sediment

Sediment samples were collected from the stream at upstream and downstream locations on the 12th January 2011 by AMC Environmental Ltd. There was a slight increase in the concentration of metals between the upstream and downstream sampling points. There was however a decrease in the levels of alkalinity and ammonia between the up and downstream sampling points. All parameters were within the typical concentration for unpolluted Irish soils.

7.1.3 7.4.3 Groundwater

Groundwater samples were collected from the on-site groundwater well on the 23rd November 2009. A sample was collected from the upgradient Carlingford Water Supply well on three occasions (16th February 2009, 30th November 2009 and 14th December 2009). The results are presented in Section 3.3 above.

The levels of iron, manganese, ammonia and total coliforms detected in the on-site well were all higher than the IGV and GTV. The remaining parameters in the on-site well were below the IGV and GTV. The results may be indicative of a very weak and aged leachate.

With the exception of hardness all parameters in the upgradient Carlingford Public Supply Well were below the IGV and GTV. The results indicate that the landfill is not impacting on water quality in the sand and gravel aquifer beneath the site.

7.1.4 7.4.3 Landfill Gas

The landfill gases methane and carbon dioxide were detected at elevated levels in three of the on-site gas wells. Landfill gases has never been detected in the on-site buildings. The buildings have been fitted with gas proof membranes. Prior to construction waste beneath and immediately surrounding the buildings were excavated out and placed on the northern part of the site. Granular fill was placed to establish formation level around the buildings. It is likely that any landfill gas migration toward the buildings is venting to atmosphere in the granular fill surrounding the buildings. While a potential pathway from the landfill to the on-site buildings exists this has for the most part been mitigated if landfill gas proof membranes have been incorporated in the construction process.

There is a housing development within 50m of the western site boundary. The presence of the stream on the western site boundary is likely to act as a natural cut off inhibiting lateral migration of gas to the west towards houses. Landfill gases were not detected in BH-2 and BH-5 which are on the north western and south western site boundary. This would indicate that lateral migration of gas is not occurring in these directions. The use of gas ventilation trenches is recommended in the Tier 2 assessment to mitigate the risk of gas migration from the northern portion of the site where elevated gas readings have been detected.

7.2 7.5 Conclusions

The GQRA has identified source-pathway-receptor risk for leachate discharge to the surface water and groundwater system, and landfill gas migration to the residential areas to the west. This is consistent with the Tier Risk Assessment which concluded that the site is a Moderate Risk Site.

The available monitoring data indicates that impacts associated with leachate migration to the stream are low. Recommendations are proposed in the Tier 2 Assessment for ongoing monitoring of surface water quality. The results of the monitoring programme can be used to confirm that the risk posed by the site to surface water quality is low.

No impacts associated with leachate migration have been detected in the sand and gravel aquifer beneath the site. Ongoing monitoring of water quality in the public supply well can be used to confirm that the risk posed to groundwater is low.

Landfill gas monitoring indicates that migration to the northwest and southwest is not occurring and the surface water stream most likely cuts off migration to the residential housing to the west. Remedial measures have been proposed as part of the Tier 2 Assessment to mitigate landfill gas migration in the northern portion of the site where elevated readings have been detected. The measures incorporate the use of gas ventilation trenches. Combined with landfill gas membranes in the wastewater treatment buildings and the stream cut off to the west the risk posed by landfill gas will be mitigated in the future.

An appropriate Assessment screening indicated that the site is unlikely to be impacting on Carlingford Lough. However as a precautionary measure The Tier 2 assessment includes a recommendation for an assessment of the Tier 2 findings by a suitably qualified ecological consultant to establish if the site poses a risk to the SPA and SAC in Carlingford Lough.

7.3 7.6 Recommendations

The recommendations of the Tier 2 assessment should be implemented in full to ensure that the risk posed by the site remains low.

APPENDIX 1

Draft GSI Source Report

Cooley Water Supply Scheme

Carlingford Boreholes

Groundwater Source Protection Zones
Draft report

March 2009

Prepared by:
EurGeol. Dr. Robert Meehan, PGeo.
Consultant Geologist

In collaboration with:
Geological Survey of Ireland

And in Partnership with:
Louth County Council

With contributions from:
Taly Hunter Williams and Monica Lee, GSI
Coran Kelly, Tobin Consulting Engineers

Document control

Draft	Date	Author	Checked
First draft	March 2009	R. Meehan	NHW
Second Draft			
Draft Final			

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1 Introduction

The Carlingford Boreholes, which form part of the Cooley Water Supply Scheme, are located in the southern suburbs of the town of Carlingford, at the eastern end of the Cooley Peninsula in northeast County Louth.

Louth County Council requested Source Protection Zone delineation for both the Carlingford Boreholes and the Ardtully Beg Boreholes from the Geological Survey of Ireland (GSI) in August 2006, in order to develop Source Protection Zones for the entire zone of contribution to the Cooley Water Supply. The Ardtully Beg Boreholes are considered in a separate report.

The objectives of the report are as follows:

- To delineate source protection zones for the Carlingford boreholes.
- To outline the principal hydrogeological characteristics of the Carlingford area.
- To assist Louth County Council in protecting the water supply from contamination.

The protection zones are delineated to help prioritise certain areas around the source in terms of pollution risk to the springs. This prioritisation is intended to provide a guide in the planning and regulation of development and human activities. The implications of these protection zones are further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The report forms part of the groundwater protection and source protection map/report suite for the county (GSI, 2009). The maps produced for the scheme are based largely on the readily available information in the area and on mapping techniques which use inferences and judgements based on experience at other sites. As such, the maps cannot claim to be definitively accurate across the whole area covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

2 Location, Site Description and Well Head Protection

The boreholes' pumping station and pump house compound are located on a narrow, third class road just off the Regional R173 road, approximately 0.9 km south-southeast of the centre of the town of Carlingford. The location of the site is shown in Figure 1.

The boreholes' area seems to constitute a zone of groundwater discharge upon first inspection, being situated within the footslope zone at the junction between a coastal lowland and the northeastern flank of a high ridge to its' southwest. The Ordnance Survey six inch map of the 1860's depicts a stream rising at the location of the pump house, with water emerging and flowing northwards through a marshy area, past Ghan House and into the sea in the southernmost portion of the Harbour (Figure 1). The area around the pump house is labelled 'Springfield' on this map.

The source was mooted as being a potential water supply when the adjacent sewerage treatment works were completed in the 1990's. At that time vast quantities of groundwater were encountered when constructing the works, 100m to the northeast of the now-utilised boreholes. An exploration borehole was then drilled to 13m depth in September 1998 and a pumping test carried out on the groundwater there, suggesting a minimum yield of 2,000m^3 per day (730,000m^3 per year)[1]. The proposal was to abstract a maximum amount of 1,200 m^3 per day.

The scheme was then commissioned in 1998, as part of the augmentation scheme for the Ardtullbeg Source, but did not begin until 2000. By then a second borehole had been drilled, immediately adjacent to the first[2].

[1] The maximum yield is given as 4,500 m^3/d, as quoted in historical Local Authority documentation on the boreholes.
[2] There are no logs available for this second borehole data on it have come from Louth County Council personnels' memories rather than logged records..

Currently, the two boreholes are active and are pumped at a combined rate of 50m^3/hr, 24 hours a day, resulting in the combined volume of 1,200 m^3/d. The groundwater is now chlorinated and fluoridated on-site and is then pumped to a reservoir with a storage capacity of approximately 2,000 m^3 at Rath, 3.5 km to the south-southwest, *via* a 200mm diameter watermain, and is then combined with water abstracted from boreholes at Ardtully Beg prior to distribution through the Cooley Water Supply piped network. The chlorination tank and chemicals are stored in the pump house and a tap is present there for raw water samples.

The pumphouse site area constitutes only *c*. 150 m^2 but is fenced off with good quality fencing, and is further surrounded by dry grassland to the east, a recently-built housing estate and the Carlingford Wastewater Treatment Works to the north, and the southern Carlingford suburbs to the west and south.

The sanitary protection of the Carlingford boreholes appears satisfactory. The bores are situated within sunken concrete chambers (*c*. 1.5 m x 1 m) that are securely covered by lockable, galvanised steel lids. The tops of the chambers are very slightly higher than the surrounding ground level. The chambers are situated to the immediate southeast of the pump house, in a tarmacadamed area. The pump control equipment and water treatment system is housed in the pump house, a separate, small brick building.

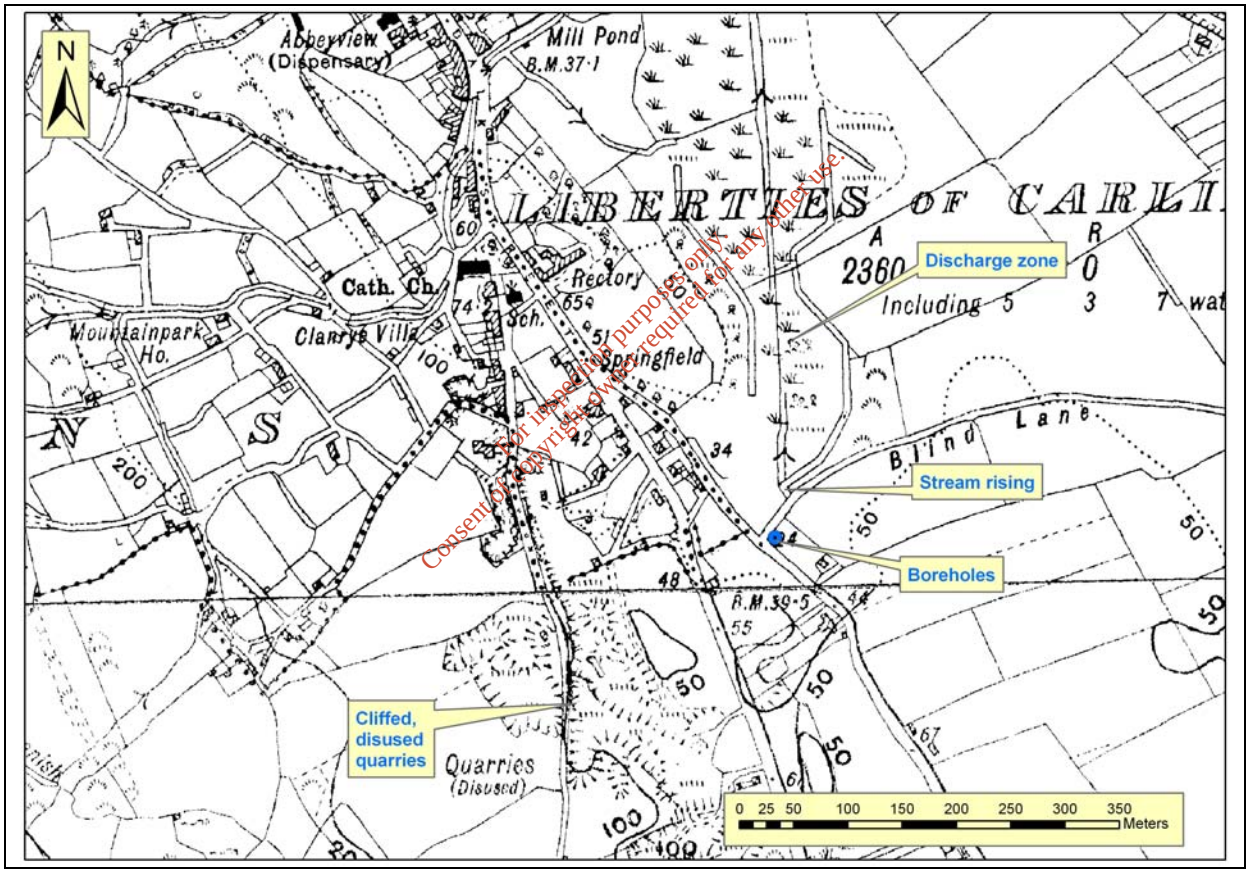

Figure 1: Location of the boreholes, as well as the rising stream and interpreted discharge zone to their immediate north. The deep, cliffed, disused quarries up-slope are also shown.

3 Summary of Borehole Details

Well Details	Well Name	
	PW1	PW2
Date Drilled	1998	1999
GSI Well Number	2929NEW123	2929NEW123
Grid Reference	319252 310894	319253 310893
Location (townland)	Liberties of Carlingford	Liberties of Carlingford
Well type	Bored	Bored
Owner	Louth Co. Co.	Louth Co. Co.
Ground elevation	7.5mAOD	7.5mAOD
Depth of borehole	13m	21.3m
Diameter of hole (mm)	250	250
Casing/screen diameter	250mm nominal	250mm nominal
Lithological Unit	Sand and Gravel	Sand and Gravel
Static water level (bgl)	3.9 mbgl	3.9 mbgl
Static water level (AOD)	3.6mAOD approx	3.6mAOD approx
Pumping water level (bgl)	6.5m approx.	6.5m approx.
Pumping water level (aOD)	1.0m approx.	1.0m approx.
Average Current Abstraction (m^3/d)	1,200 combined yield	
Hours pumping	24 hours per day	24 hours per day
Depth of pump	~12 m	~19 m
Depth to bedrock	>13 m	>13 m (assumed)
Maximum Drawdown (m)	2.5m	2.5m
Estimated Safe Yield	2,000m^3/day	
Treatment	Chlorinated and raw water tap available	
System	Submersible pump to mains *via* reservoir	

4 Methodology

Details about the borehole source such as date commissioned, historical data and outline abstraction figures were obtained from County Council personnel. As well as this, the data collection process included the following:

- Interview with the acting caretaker, 23/02/2009.
- A desk study of existing geological and hydrogeological information was completed on 18/03/2009 and 19/03/2009, procured predominantly within the relevant GSI databases and maps.
- Detailed field survey of the subsoil geology, the hydrogeology and vulnerability to contamination was carried out by walkover stream surveys, logging of outcrops and exposures, and hand augering. This was completed on 23/03 and 25/03, 2009.
- Auger drilling of 9 no. boreholes was carried out by the GSI to ascertain depth to bedrock and subsoil permeability between 28/05/2007 and 05/06/2007.
- Analysis of field study results, previously collected data and hydrogeological mapping were used to delineate protection zones around the source.

5 Topography, Surface Hydrology and Land Use

The boreholes are located in Hydrometric Area 6 of the Neagh-Bann River Basin District. The area's hydrology is characterised by a number of unnamed mountain streams rising high on the mount backslopes and flowing short distances into Carlingford Lough. These streams, forming a small but discrete hydrological area, occur only along the eastern flank of the Cooley Mountains between

Omeath at the north, where they are flanked by the Newry River Catchment, and the Bush at the south, where they bound the Big River Catchment. .

North of Carlingford Town the land rises steeply from the sea to the mountain summits, at an average topographic gradient of 0.33 (Figure 2). South of the town and in the vicinity of the boreholes the gradients to the west are not as steep, at an average of 0.19, and a broad coastal plain opens up to the southeast. This area is comprised of gently undulating to rolling topography, with some small pockets of relatively hummocky terrain. The general altitude here is usually 5m-25m ASL.

The natural drainage density in the immediate vicinity of the source on its' northern side is high owing to the presence of a flat, waterlogged area of alluvium/peat there (Figure 1). Further north and northwest the steep mountain slopes and associated streams also mean relatively high drainage densities where they feed surface water into the sea. A particularly long and voluminous stream flows through the centre of Carlingford Town, 850m north of the source. The artificial drainage density in the upland area to the north is low, however, as streams are relatively common and drains are not required.

To the east, south and west of the source, there are few surface drainage features, either natural or anthropogenic; only 1 no. stream is seen at Catherine's Grove, 1km to the southeast, at the base of a deep glacial meltwater channel. It is interesting to note that, 450m south of the source, 2 adjacent streams rise from a marked bedrock scarp (see section 6.3 below) but each disappears underground after a distance of 50m-100m. Cut drainage ditches are rare in this overall area.

Small ponds and pools occur every now and then at the base of marked hollows to the south and southeast of the source; these seem to be no more than areas where the water table breaks the surface, and have no inflow or outflow features.

The land in the vicinity of the source is split between two land uses; agricultural and built land. South of the source, and for several kilometres south, southeast and southwest, the land is primarily agricultural, dominated by sheep grazing, with some dairying and cattle rearing. To the east between the source and the sea, both pasture and arable land is seen. Though the lowlying area immediately north of the source comprises wet grassland and an area of improved amenity grassland in a park, to the north and northwest of the source, built land comprising buildings and artificial surfaces dominates in and around Carlingford Town. Further to the north and northwest, as the land rises into the uplands, montane heath and scrub occurs.

The area immediately adjacent to the source includes a number of new housing estates to the north and northwest, as well many older residences to the west. These connect to the Carlingford mains sewer but some of the individual houses to the southwest are served by septic tanks, particularly those higher up the hillslopes. The sewerage works themselves are situated 85m northeast of the source. A nursing home lies 100m to the west-southwest of the source, and a farmyard 75m to the east. There also occurs a cemetery 135m to the southeast of the source, and disused quarries 250m to the southwest.

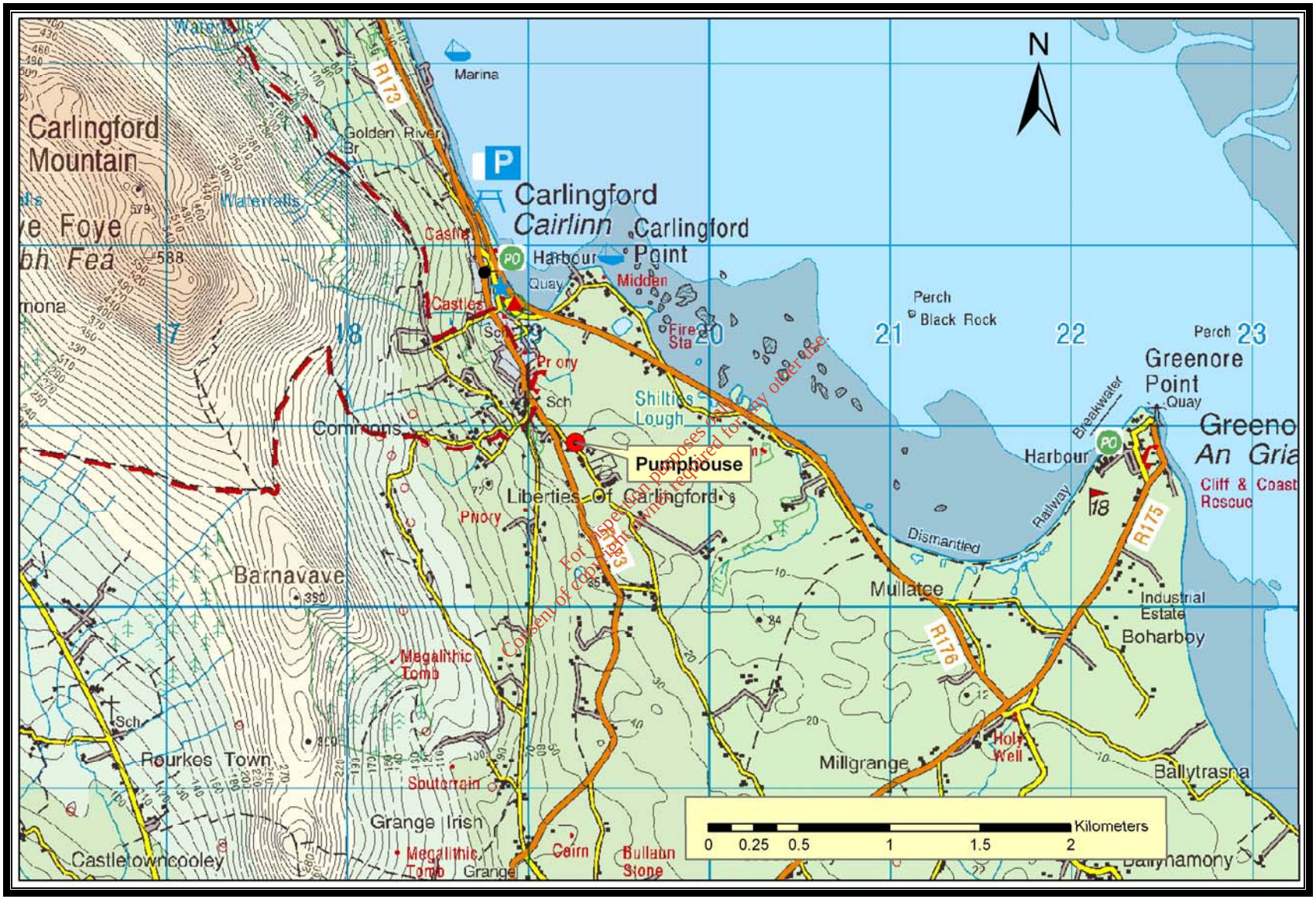

Figure 2: Topography of the area around Carlingford. The high mountains to the west are clearly seen, as are the main hydrological features.

Figure 3: Land use around the source. The sewerage works comprise the bouidlings immediately northeast of the pumphouse. The dominance of well drained pasture land to the south and southwest is seen, as are the arable fields to the east and the built area of Carlingford to the north. Montane heath and scrub is also seen to the west on the high mountains slopes.

6 Geology

6.1 Introduction.

This section briefly describes the relevant characteristics of the geological materials that underlie the Carlingford boreholes source locality. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections. Geological information was initially taken from a desk-based survey of available data, which comprised the following:

- Geraghty, M., 1997. Geology of Monaghan-Carlingford: A geological description of Monaghan-Carlingford, to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 8/9, Monaghan-Carlingford.
- The Subsoils Permeability Map and Groundwater Vulnerability Map of County Louth, drawn up as part of the National Groundwater Protection Scheme (GSI, 2009).
- Meath Groundwater Protection Scheme (Woods *et al*., 1995).
- Information from geological mapping in the nineteenth century (on record at the GSI).
- Information from Mineral Exploration Open Files, also held by the GSI.
- Data from Quaternary mapping of County Louth, carried out by the GSI (O'Connor, 1998).
- Data from the EPA/Teagasc Subsoils Map for County Louth.
- Data from the Teagasc Preliminary Reconnaissance Soil Map of County Louth.

As well as this, detailed field survey of the geology was carried out in the area around the source by walkover stream surveys, logging of outcrops and exposures, and hand augering. This was completed in February 2009.

6.2 Bedrock Geology.

According to the 1:100,000 bedrock sheets of the region (Geraghty, 1997), the area around the boreholes is underlain by Undifferentiated Dinantian limestones (Dinantian Mixed Sandstones, Shales and Limestones). These Dinantian rocks unconformably overlie Ordovician-Silurian age greywacke and schists of the Inishkeen Formation, which are the oldest rocks in the Cooley Peninsula. The Carboniferous and Silurian rocks have been intruded by younger Tertiary igneous rocks, exposed on the higher ground to the west and northwest where they have been folded and faulted to form the Cooley Mountains.

The Undifferentiated Dinantian limestones (Dinantian Mixed Sandstones, Shales and Limestones) have not been subdivided into discrete facies units as detailed mapping of the bedrock has not been carried out in the area. The limestone rock in this part of County Louth is however generally described as pale grey, medium to fine grained, and bedded. Some dolomite units occur in places.

Faulting has occurred in the general region around the source, with a major fault and unconformity occurring 290m to the northeast at the boundary with the Inniskeen Formation, but no faults have currently been delineated in the immediate source locality.

A relatively extensive area of bedrock outcrop occurs immediately west of the boreholes, across the road from the site. The majority of this outcrop takes the form of a 25m-35m high cliff, which has been quarried at certain localities historically and which stretches for *c*. 800m north-south. Small areas of outcrop and subcrop also occur further west and northwest, up-slope.

6.3 Subsoil Geology.

Subsoils mapping was carried out by the author in 2001 while working at Teagasc on the EPA /Teagasc Soil and Subsoil Mapping Project. Refined mapping of subsoils was carried out throughout County Louth and in the Carlingford locality for the current Groundwater Protection Scheme Project (GSI, 2009). This information forms the basis for subsoil permeability assessments of the area, also carried out for the current project. Further information was gathered from GSI boreholes drilled around the source in May and June 2007.

The subsoils around the source comprise a mixture of coarse- and fine-grained materials. Granite tills, tills derived from shales and sandstones and sand/gravel (often at depth) are the dominant subsoils in the area, with more restricted areas of sands and gravels, limestone bedrock outcrop, peat and alluvium occurring (Figure 4). In general, subsoils are relatively shallow west of the source on the hillslopes, but are considerably deeper to the east of the source on the more lowlying and gently undulating terrain.

- ‘Till’ or ‘Boulder clay’ is an unsorted mixture of coarse and fine materials laid down by glacier ice during the last Ice Age. Till is the dominant subsoil type south, west and north of the source.
- The tills are varied in their dominant lithology, being dominated by granite on the hillslopes west of the source, by limestone in pockets on the lower ground to the south and southeast and by shale to the north and east, but all of tills are classed as being of moderate permeability. The tills encountered in the boreholes drilled by GSI around the source in May and June 2007 were described using BS 5930 as either silty sandy GRAVEL or silty GRAVEL.
- The depth to bedrock in the areas where till occurs on the hillslopes west and southwest of the source is generally less than 5m, and often less than 3m. The till to the east of the hillslopes and the source, in the lowland area, is much deeper.
- It seems that, though the area east of and including the source itself is mapped on the Teagasc subsoil map as being underlain by till, from detailed mapping and associated augering for this Source Protection report much of this area is underlain by deep glaciofluvial sands and gravels derived from shales and sandstones. These were deposited by wide meltwater rivers during deglaciation, when the ice sheets of the last Ice Age melted. The depth to bedrock in the sands

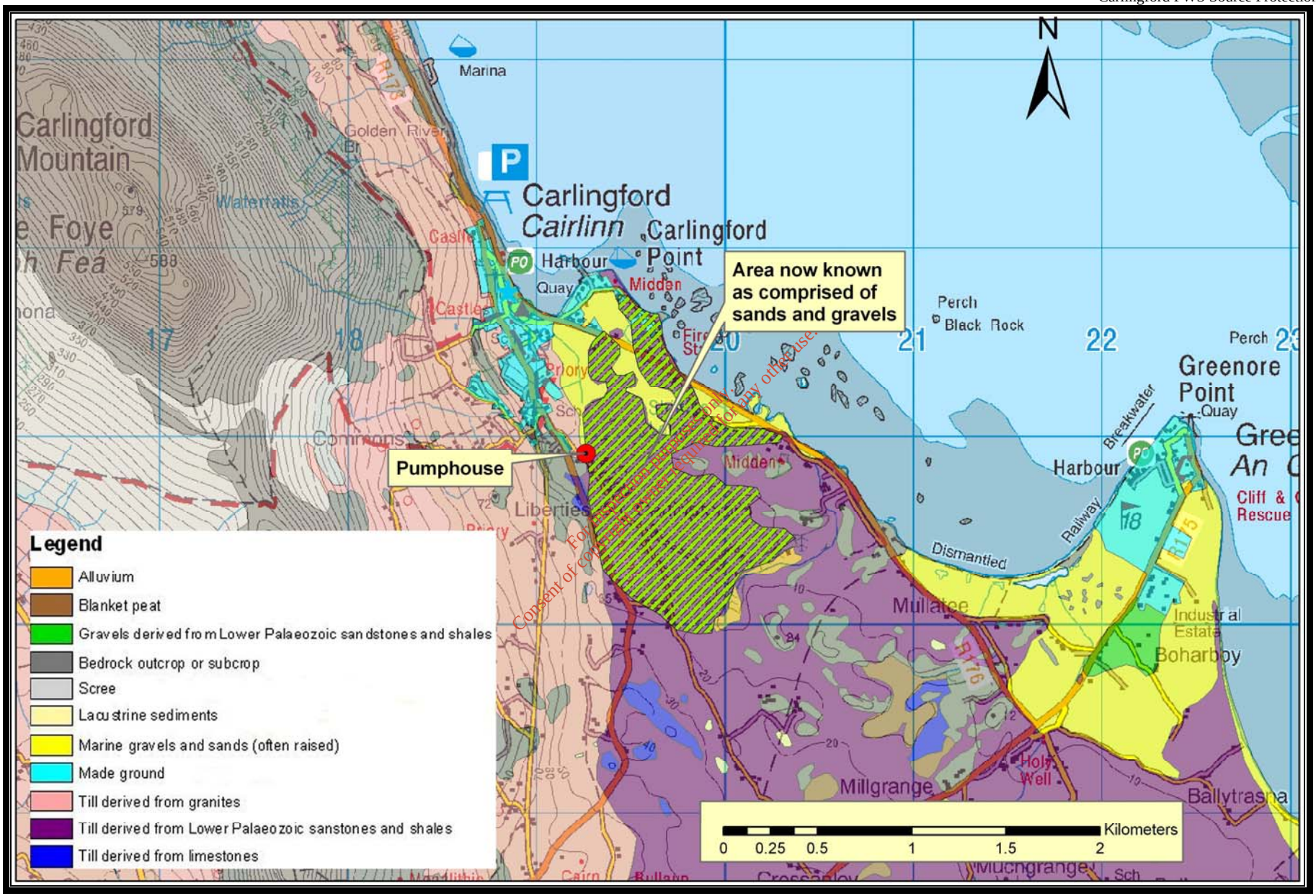

Figure 4: Subsoils geology map of the area around the Carlingford Source. The area now known to be sands and gravels is also shown.

and gravels to the east of the source is generally deep at >12m, though pockets with depths <5m do occur.

- Immediately north of the source, for a distance of 750m and as far as the coastline, a narrow, flat, low-lying area of postglacial deposits occurs. These have accumulated in this lowlying area since the last Ice Age, and have been mapped as 'Marine sands and gravels' on the Teagasc subsoil map. From examination during field work this was seen to be the case in the northern portion of the area, but at the south close to the source the material comprises a mixture of interbedded peat and alluvium. The alluvium material is dominated by CLAY but also hosts interbedded SAND, and seems to overlie glaciofluvial sands and gravels, as seen in the source borehole logs and from mapping around the locality.
- To the west and southwest of the source, bedrock protrudes through the deep glacial and postglacial subsoils within the cliffed outcrop area mentioned in Section 6.2.
- In and around Carlingford itself, much of the subsoils have been covered by 'Made' ground; built land, residential gardens and concreted/tarmacadamed areas. This 'Made' material is underlain by till and bedrock at or close to the surface, similar to the areas immediately adjacent to it.

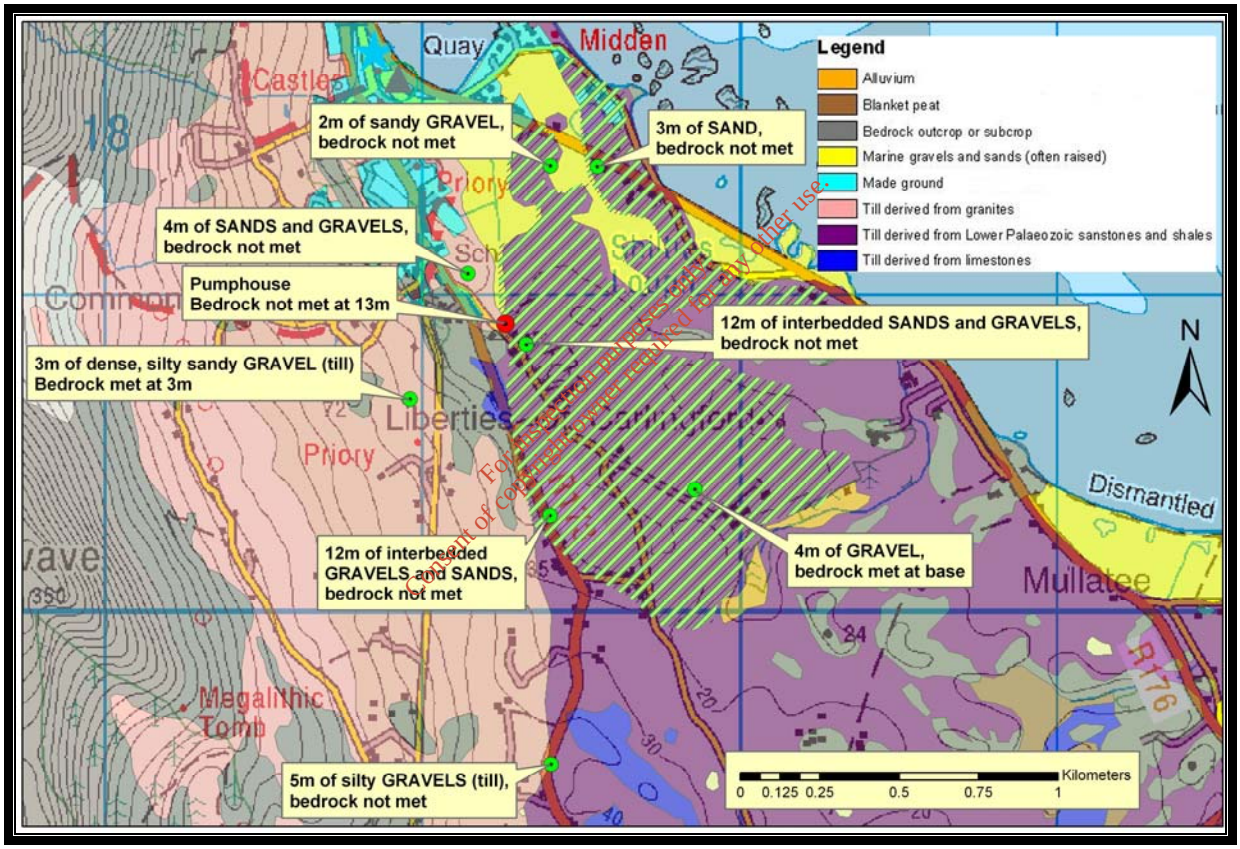

Figure 5: Details of boreholes bored by GSI in summer 2007 around the source. The logs from these, along with mapping of exposures in the locality around the source, were used to delineate the area of sands and gravels constituting the source aquifer (shown as green hatch).

7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. This means that vulnerability relates to the thickness of the unsaturated zone in the sand/gravel aquifer, and the permeability and thickness of the subsoil in areas where the sand/gravel aquifer is absent. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI

Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons *et al.*, 2003).

The groundwater supply source is the water table hosted in the sand/gravel beneath the ground surface. For the purposes of vulnerability mapping in the immediate vicinity around the boreholes, the "**water table**" is the target, as this lies above the top of the bedrock. Further west and southwest, and up-slope, where the subsoil is thin till of moderate permeability at an elevation higher than that the water table than that at the boreholes, then the "**top of the rock**" is the target[3].

- North, west, south and east of the source, the permeability of the till subsoil is interpreted to be "**moderate**" (see Figure 4 for the pattern of subsoils in these areas). Immediately north of the source, the permeability of the alluvium/peat subsoil is interpreted to be "**moderate**", and to the east and southeast the permeability of the sand/gravel subsoil is "**high**" (see Figure 4)**.**
- Depth to bedrock varies from being greater than 13 m around and to the east of the source to zero where the rock outcrops occur along the cliffs to the west and southwest.
- At subsoil thickness of less than 3m, as indicated by the outcrop, subcrop and drilling data, bulk permeability becomes less relevant in mapping vulnerability across wide areas (as opposed to specific sites). This is because infiltration is more likely to occur through 'bypass flow' mechanisms such as cracks in the subsoil. Based on the general depth to bedrock, a vulnerability classification of **"extreme"** has been assigned in these areas of shallower subsoil.
- Where subsoil thickness is greater than 3m, the vulnerability classification is **"high"**, within this having various specific combinations of permeability and subsoil thickness.

Depth to rock and depth to the water table interpretations are based on the available data cited here. However, depth to rock can vary significantly over short distances. As such, the vulnerability mapping provided will not be able to anticipate all the natural variation that occurs in an area. The mapping is intended as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems. The potential for discrepancies between large scale vulnerability mapping and site-specific data has been anticipated and addressed in the development of groundwater protection responses (site suitability guidelines) for specific hazards. More detail can be found in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

8 Hydrogeology

This section presents the current understanding of groundwater flow in the area of the source boreholes and their feeder catchment. The interpretations and conceptualisations of flow are used to delineate source protection zones around the boreholes.

Hydrogeological and hydrochemical information for this study was obtained from the following sources:

- GSI Databases.
- Fitzgerald, D. and Forrestal, F. (1996) Monthly and Annual Averages of Rainfall for Ireland 1961-1990. Meteorological Service, Climatological Note No. 10, UDC 551.577.2(415).
- Historical Louth County Council hydrochemistry data.
- EPA Groundwater Monitoring Data from the Carlingford Boreholes.
- Hydrogeological and permeability mapping carried out by the author.
- A drilling programme carried out by the GSI to ascertain depth to bedrock and subsoil permeability in May and June 2007.

[3] In areas where the water table is below the top of the bedrock, the thickness of the unsaturated zone within the bedrock is not taken into consideration in vulnerability mapping, as fractured bedrock has high permeability regardless.

8.1 Meteorology and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and assumed to consist of input (*i.e*. annual rainfall) less water loss prior to entry into the groundwater system (*i.e*. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as it will dictate the size of the zone of contribution to the source (*i.e*. the outer Source Protection Area).

At Carlingford therefore, the main parameters involved in recharge rate estimation are: annual rainfall; annual evapotranspiration; and a recharge coefficient. The recharge is estimated as follows.

Annual rainfall: 1,067 mm.
The contoured data map of rainfall in Ireland (Met Eireann website, data averaged from 1961-1990) show that the boreholes are located between the 1000 mm and 1200 mm average annual rainfall isohyet. The closest meteorological station to the boreholes is at Carlingford, which has average annual rainfall of 1067 mm (Fitzgerald and Forrestal, 1996). Given that the topography and altitude at the Carlingford gauging station (1 km to the north-northwest) are similar, we can therefore interpret that annual rainfall is calculated as *c*. 1067 mm for the boreholes' locality.

Annual evapotranspiration losses: 450 mm.
Potential evapotranspiration (P.E.) is estimated to be 475 mm $yr.^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E., to allow for seasonal soil moisture deficits.

Annual Effective Rainfall: 617 mm.
The annual effective rainfall is calculated by subtracting actual evapotranspiration from rainfall. Potential recharge is therefore equivalent to this, or 617 mm/year.

Runoff losses: 142 mm.
Runoff losses are assumed to be 23% of potential recharge. This value is based on an assumption of *c*. 20% runoff for 95% of the area[4] (high or moderate permeability subsoils and soils, no drains or surface streams), and 80% runoff over 5% of the area due to thicker, less permeable subsoil or shallow subsoil with less permeable bedrock, less permeable subsoil (Irish Working Group on Groundwater, 2004).

The bulk *recharge coefficient* for the area is therefore estimated to be 77%.

These calculations are summarised as follows:

Average annual rainfall (R)	1067 mm
estimated P.E.	475 mm
estimated A.E. (95% of P.E.)	450 mm
effective rainfall	617 mm
potential recharge	617 mm
recharge coefficient for moderate K	80%
recharge coefficient for low K	20%
runoff losses	23%
bulk recharge coefficient	77%
Recharge	**475 mm**

It should be noted that on the Draft National Recharge Map produced by CDM Ireland and Compass Informatics (ERBD, 2007), the area around the source has been classified as having a recharge rate

[4] The 'area' here is the expected, or estimated, potential zone of contribution from preliminary assessments of the topography, soils, subsoils and bedrock geology of the area.

between 51mm and 100mm per year. This was, however, calculated based on the assumption that thick, low permeability till underlies the land surface here.

The sand and gravel aquifer at Carlingford therefore receives 475mm of direct recharge from above through soils and subsoils on an annual basis, as well as indirect recharge from surface run-off/shallow groundwater flow from the higher land to the west and southwest.

8.2 Groundwater Levels, Flow Directions and Gradients.

The flat, lowlying area to the north effectively has water at the land surface, being a marshy area, and groundwater seems to discharge around the edges of this, as shown on the Ordnance Survey six inch map of the 1860's, where streams rise (Figure 1). The streams rise in the footslope zone at the base of the surrounding sand/gravel hills, on which the source boreholes have been drilled, and flows northwards.

Groundwater flow to the sands and gravels feeding the source area is expected to be from the hillslopes to the southwest, from southwest to northeast, within the limestone bedrock aquifer and generally following topography. With this in mind the GSI drilled a borehole up-gradient of the source in the topographically higher till/shallow bedrock area, 320m southwest (NGR 318960 310670). This did not meet the water table at 3m depth, but the water table in this area is expected to be relatively steep nonetheless, mirroring topography and fed under steep head downslope to the sands and gravels. The fact that the water at the source is very hard (see flowing section 8.3) suggests that the majority of its chemical signature is derived from the limestone, with the relatively steep groundwater gradient of the hillslopes constantly feeding water northeast towards the source.

The water that feeds into the sands and gravels area then is then expected to have a more shallow water table. A borehole drilled into these 620m south-southeast (NGR 319401 310303, and again 'up-gradient') did not meet the water table at 12m depth. The altitude of this hole at 29m ASL suggests a groundwater gradient no steeper than 0.02 between the two boreholes in the sands and gravels. The borehole records for the source show that the groundwater is unconfined in the sands and gravels, with the water table at 3.9m below ground level in the 13m deep borehole.

This suggests a relatively flat groundwater table in the area of the sands and gravels and corroborates that estimated by An Foras Forbartha/EGSI in 1982 (1:60, or 0.017).

8.3 Hydrochemistry and water quality.

The majority of the available water quality data for the Carlingford boreholes source is from EPA Monitoring data, which has been collected several times a year at Carlingford since 2007. As well as this, water quality results from the initial pumping test in 1998 were also utilised. The data on trends in water quality are summarised graphically in Table 2. The following key points are identified from the data.

- The water is generally "very hard" with an average total hardness of *c*. 217 mg l^{-1} (equivalent $CaCO_3$) calcium-bicarbonate hydrochemical signature. The values are typical of groundwater from limestone and therefore show that though the groundwater is sourced in gravels that are dominated by shales and sandstones, this has little or no effect on the hydrochemical signature derived from the bedrock to the west of, northwest of, and under the source. The hardness values are higher than the recommended EPA threshold value and Drinking Water Standard of 200mg/L $CaCO_3$, which are however based on palatability and formation of limescale, rather than on health grounds.
- Electrical conductivity values as sampled by the EPA are of 461-521 µS cm^{-1}, with an average of 485µs/cm. This was similar to values found at the time of initial pump testing (469 and 484 µS cm^{-1}).

- Faecal coliforms were absent from the water on all occasions sampled. As well as this, on no occasions were ammonia values greater than the GSI threshold value (0.15 mg l^{-1}) recorded; ammonia levels were consistently below 0.1 mg l^{-1}).
- One 2 no. occasions, total coliforms were present in the samples taken (10 no. on 27/07/07 and 2 no.on 29/10/08). However, such low values may be due to sampling or analysis error so the results are not considered noteworthy.
- Nitrate concentrations in available samples since 2007 range from 12.2 mg l^{-1} to 16.6 mg l^{-1} (average is 14.82 mg l^{-1}). There are no reported exceedances above the EU Drinking Water Directive maximum admissible concentration of 50 mg l^{-1}, or the GSI threshold value of 25 mg l^{-1}. The area around the source, though relatively densely populated, has a relatively low density of septic tanks owing to the presence of the sewer network to the north and west. Further from this, little tillage is practiced around the area up-gradient of the source and, excepting the cliffed outcrop localities along the scarp to the west, depths to bedrock are moderately deep. The source area itself has a CLAY cap above the sands and gravels of 10m depth. Therefore, the relatively low nitrate levels at Carlingford are probably due to a combination of the above factors. It is noteworthy, however, that nitrate levels in 2007 and 2008 are generally *c*. 3-4 times what they were in 1998: the nitrate data have therefore seem to have shown an upward trend in recent years and this chemical signature should be monitored closely in the near future.

Sample date	Conductivity µS/cm	Ammonia mg/l N	Chloride mg/l Cl	Iron µg/l Fe	Total coliforms No./100ml	Faecal coliforms No./100ml	Nitrate mg/l NO_3	Sodium mg/l Na	Potassium mg/l K	Total hardness mg/l $CaCO_3$
15/09/98	484	<0.01	17.7	<50	nm	nm	4.6	10.2	1.5	229
16/09/98	469	<0.01	18.1	<50	nm	nm	4.7	10.5	1.8	239
27/07/07	486	0.02	14	14	**10**	<1	12.6	11.5	1.7	222
30/09/07	516	0.01	16	<2	<1	<1	15.4	12	1.9	253
24/10/07	Nm	0.1	17	10	<1	<1	16.6	9.5	1.5	249
30/11/07	475	0.03	15	<2	<1	<1	16.5	11.5	1.7	261
11/01/08	414	0.02	15	<2	<1	<1	16.1	11.5	1.7	231
04/06/08	530	<0.007	18.1	<5.0	<1	<1	12.2	8.7	1.3	208
30/07/08	493	0.088	13.7	<5.0	<1	<1	14.5	10.6	1.6	218
29/10/08	504	0.059	14	<5.0	**2**	<1	14.9	13.1	1.9	280
11/12/08	526	0.021	16	12.6	<1	<1	14.6	11.5	1.9	233

Table 1: Summary hydrochemical data for Carlingford Boreholes, 1998 and 2007-2008.

- Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate contamination, with levels higher than the 30 mg l^{-1} usually indicating significant contamination (Daly, 1996). Chloride concentrations range from 13.7 to 18.1 mg l^{-1} (average 15.7 mg l^{-1}), suggesting that contamination from organic wastes does not seem to be an issue at Carlingford. The chloride levels are also interesting in that in a coastal area such as Carlingford, background concentrations of chloride are expected to be 30-35 mg l^{-1} due to rainwater enrichment by evaporating seawater, but this does not seem to be the case at the source.
- The levels of potassium are consistently well below the GSI threshold value of 4 mg l^{-1}. Again, this shows consistent levels, averaging at 1.68 mg l^{-1}, with a maximum of 1.9 mg l^{-1} (30/09/2007, 29/10/2008, 11/12/2008). The potassium:sodium (K/Na) ratio never exceeds the GSI threshold of 0.35, with the highest value at 0.165 (11/12/2008). These data suggest no organic waste sources, and the K/Na ratio again seems to rule out farmyard waste as an issue.

- The levels of iron range from <2 to 14 µg l^{-1} at Carlingford, with records showing that iron never exceeds the maximum admissible concentrations (0.20 mg l^{-1}). This also suggests an absence of any influence of effluent from organic wastes.
- Normal levels of trace metals were identified, safe for drinking, and the water is free of chlorinated hydrocarbons, solvents and pesticides.
- Overall, the samples from the source boreholes do not indicate significant contamination or pollution of these wells.

8.4 Aquifer Characteristics.

The sands and gravels through which the borehole is drilled, though previously unmapped at adjacent localities around the Carlingford Source, have been seen as extensive following the mapping and drilling carried out for the current project. The deposit hosting the water table that the source abstracts from is therefore classed as a **Locally Important Sand & Gravel aquifer (Lg)**. The probable extent of this aquifer is depicted in Figures 4 and 5, and is also referred to in Section 6.3 above. The aquifer thickness is unknown but is at least 12m thick both 80m southeast and 630m south of the source.

Bodies of sands and gravels with similar geometries to that outlined above have previously been mapped on the southern side of the Cooley Peninsula, at Ardtully Beg, Ballynamoney and The Bush. These materials form part of the 'Dundalk Gravels' Groundwater Body of the GSI, for which some hydrogeological data are available. At Ardtully Beg, a transmissivity of about 1000 m^2/d^{-1} and a specific yield of 0.1 have been reported (An Foras Forbartha/GSI, 1982). This equates to bulk permeabilities of between 1-40 m/d^{-1} and the porosity is assumed to be in the order of 0.07, from work carried out by GSI on other sand and gravel sources around Ireland. The groundwater at Carlingford is likely to be unconfined.

Though not drawn from at the source, the underlying Undifferentiated Dinantian limestones (Dinantian Mixed Sandstones, Shales and Limestones) are classified as a **Locally Important Aquifer - bedrock which is generally moderately productive (Lm).**

8.5 Conceptual Model.

- The Carlingford pumping wells are installed in glaciofluvial sands and gravels which are classified as a **Locally important sand and gravel aquifer (Lg)**.
- The saturated aquifer thickness at the source is 15.1m.
- Owing to the presence of the water table within the sands and gravels at 3.9m bgl at the source, the aquifer seems unconfined.
- The gravel aquifer is underlain by Undifferentiated Dinantian Limestones which are classified as a **Locally important aquifer - bedrock which is generally moderately productive (Lm).**
- Groundwater flow within the sand and gravel aquifer is intergranular, whereas in the bedrock beneath this and up-gradient of it to the southwest is through fractures and fissures in the limestone.
- The higher hillslope area to the west and southwest of the Carlingford Source is underlain by these Undifferentiated Dinantian limestones (Dinantian Mixed Sandstones, Shales and Limestones) and has few surface streams and rare drainage features. The absence of surface drainage suggests that potential recharge readily infiltrates into the groundwater system here.
- The limestone as seen in the adjacent quarries in this area to the west has a well developed fracture system, but does not seem to have undergone significant karstification. This is also shown by the absence of dolines, swallow holes, springs, dry valleys and other karst features in the area.
- The water table is interpreted to be deep in the bedrock in this area, as no seeps or springs occur in the cliffed bedrock area west of the source.
- Groundwater flow through this bedrock to the sands and gravels feeding the source area is expected to be from southwest to northeast, following topography.

- The precise pathways of groundwater flow in the limestone up-slope of the source, as well as the flow depths, are not known.
- The groundwater gradient in the limestone to the southwest is steeper than that in the sands and gravels, which has been calculated as no greater than 0.02.
- At the groundwater discharge zone suggested by the Ordnance Survey six inch map of the area, springs seem to emerge close to the borehole locality, in a low hollow at the base of a regional topographic high. The hollow is surrounded by thick sands and gravels and is fed primarilty by groundwater from the limestone to the southwest.
- The bedrock is relatively close to the surface in the area to the immediate west and southwest of the source, but is deep at the source itself, with the water emerging through the permeable sand and gravel deposits which act as a 'window' for flow, as well as through a capping veneer of thick clay.
- Diffuse recharge dominates in this area. The subsoil over 95% of the area is either highly or moderately permeable, and to the west and southwest of the source is relatively thin (<5m), with much of the area to the immediate east and southeast being of thick, high permeability sands and gravels: these materials allow a very high proportion of recharge to occur through them.

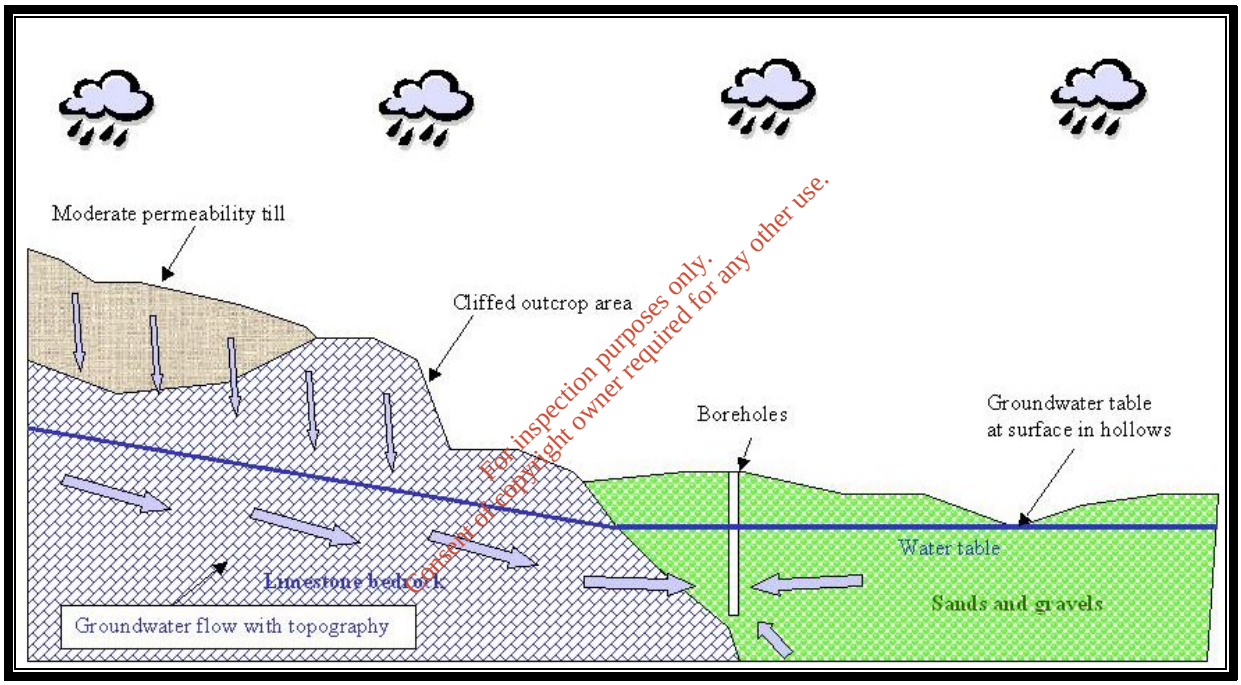

Figure 6: Three-dimensional conceptual model for the Carlingford boreholes source, with groundwater being fed into the permeable sands and gravels from the vertically higher bedrock to the west and southwest.

- The total diffuse recharge amount occurring over the catchment is therefore estimated at an annual average recharge of 475 mm per year.
- Overall, the samples from the source boreholes do not indicate contamination or pollution of these wells.

9 Delineation of Source Protection Areas

This section describes the delineation of the areas around the source that are believed to contribute groundwater to it, and that therefore require protection. The areas are delineated based on the conceptualisation of the groundwater flow pattern, as described in section 8.2 and presented in Figure 7.

Two source protection areas are delineated:

- Inner Protection Area (SI), designed to give protection from microbial pollution.
- Outer Protection Area (SO), encompassing the zone of contribution (ZOC) to the springs.

9.1 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. **the zone of contribution (ZOC)**, which is defined-as the area required to support an abstraction from long-term recharge.

The ZOC is controlled primarily by (a) the total discharge, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. The shape and boundaries of the ZOC were determined using hydrogeological mapping, water balance estimations, and conceptual understanding of groundwater flow. Given the limited amount of calibration data available, a full groundwater numerical model was not undertaken. The current abstraction rate + 50% (1800 m^3 d^{-1}) was used to estimate the area required. This is to allow for a possible increase in abstraction and also to allow for an expansion of the ZOC during dry weather. The resulting boundaries and the uncertainties associated with them are described as follows:

The **southwestern boundary** is defined using the topographic ridge to the west/southwest at Barnavave, as well as the boundary of the Undifferentiated Dinantian limestone bedrock with the granite of the mountain. The Barnavave ridge is a surface watershed and is assumed to be a groundwater divide, and the aquifer flowpaths are assumed to begin where the limestone begins. As the bedrock is a locally important aquifer aquifer that has relatively high transmissivities it is possible that groundwater flowing from the lithological boundary divide could reach the base of the ridge where the borehole is situated even though the boundary is just over a kilometre distant. No significant divides occur between this divide and the source.

The **northeastern boundary** is on the down gradient side of the borehole. Estimates from semi-analytical equations indicate that the boreholes could draw water from up to 50m distant, however this is uncertain and it is considered that a precautionary arbitrary distance of 100m is used to allow for errors and variability in the aquifer parameters.

The **northern and southern boundaries** are based on topography, due to the relatively uniform gradients in these areas the boundaries are difficult to delineate precisely.

The boundaries delineated above cover an area of about 1.38 km^2 which is far greater than the area needed to supply the boreholes.

9.2 Inner Protection Area

According to "Groundwater Protection Schemes" (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100-day time of travel (ToT) to the supply. Estimations of the extent of this area are made using Darcy's Law as follows:

For glaciofluvial sands and gravels, with a permeability (K) value of 40 m d^{-1}, porosity (n) of 0.07 and a gradient (i) of 0.017 the velocity (V) can be estimated as follows;

$$V = (K.i) / n$$
$$V = 9.71 \text{ m } d^{-1}$$

This means that in 100 days groundwater will move approximately 970m in the sands and gravels.

10 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones (see Table 3). In practice, this is achieved by superimposing the vulnerability map (Figure 6) on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an Inner

Protection area where the groundwater is highly vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present around any given source.

Four groundwater protection zones are present around the source as illustrated in Table 2. The final groundwater protection zones are shown in Figure 9.

VULNERABILITY RATING	SOURCE PROTECTION	
	Inner	*Outer*
Extreme (E)	**SI/E**	**SO/E**
High (H)	**SI/H**	**SO/H**
Moderate (M)	Not present	Not present
Low (L)	Not present	Not present

Table 2: Matrix of Source Protection Zones at Carlingford

11 Potential Pollution Sources

There are a large number of houses and farmyards within the ZOC. Land use in the vicinity of the source is described in Section 5; within the ZOC, agriculture is the main land use. Disused quarries occur 250m to the southwest, the sewerage works themselves are situated 85m to the northeast, and a cemetery is situated 135m to the southeast.

The hydrochemical data do not indicate significant contamination or pollution of the boreholes at the source. However, as nitrate levels have risen fourfold in the 8 years since the source has been in operation, these levels should be monitored closely.

The main hazards associated with the ZOC are therefore considered to be agricultural (farmyards leakage, landspreading of organic and inorganic fertilisers) and oil/petrol spills. Though domestic septic tanks and treatment systems are not a major problem as is, the installation of any new systems should be monitored closely. The location of these activities in any part of the ZOC categorised as 'extremely' vulnerable presents a potential risk, given rapid travel time through the underlying bedrock and lack of attenuation by subsoils. These are delineated as red zones on Figures 8 and 9.

Detailed assessments of hazards have not been carried out as part of this study.

12 Conclusions

- The boreholes at Carlingford, including the water supply source, are located in, and supplied by, a previously unmapped sand and gravel aquifer of local importance.
- The boreholes are drilled adjacent to a groundwater discharge zone which was historically mapped as having a rising stream, and was labelled 'Springfield'.
- The majority of the water pumped from the source is however fed by a locally important bedrock aquifer to the immediate southwest, which is topographically higher than and has a steeper groundwater gradient than that in the lower-lying sands and gravels.
- The ZOC has been delineated for the boreholes based on the assumption that the majority the ZOC comprises this higher bedrock area.
- Due to the rapid groundwater velocities in the sands and gravels, it is considered that groundwater in a major part of the ZOC could potentially reach the spring within 100 days. Therefore the Inner Protection Area for the Carlingford Boreholes is relatively large.
- The ZOC as delineated covers 1.38 km^2.
- Available data suggests that there is little contamination at the source from organic sources, but as nitrate levels have increased fourfold in the 8 years since the source went into production, and as the groundwater is unconfined, these levels should be monitored closely.

- The groundwater in the Source Protection Area ranges in vulnerability from Extreme to High.
- The Protection Zones delineated in this report are based on the current understanding of groundwater conditions and on the available data. Additional data obtained in the future might indicate that amendments to the boundaries are necessary.

13 Recommendations

It is recommended that:

1. The potential hazards in the ZOC should be located and assessed, especially given the high number of farmyards and houses up-gradient of the source in the ZOC.
2. A full chemical and bacteriological analysis of the **raw** water should be carried out on a regular basis by the Local Authority.
3. Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the boreholes.

14 References

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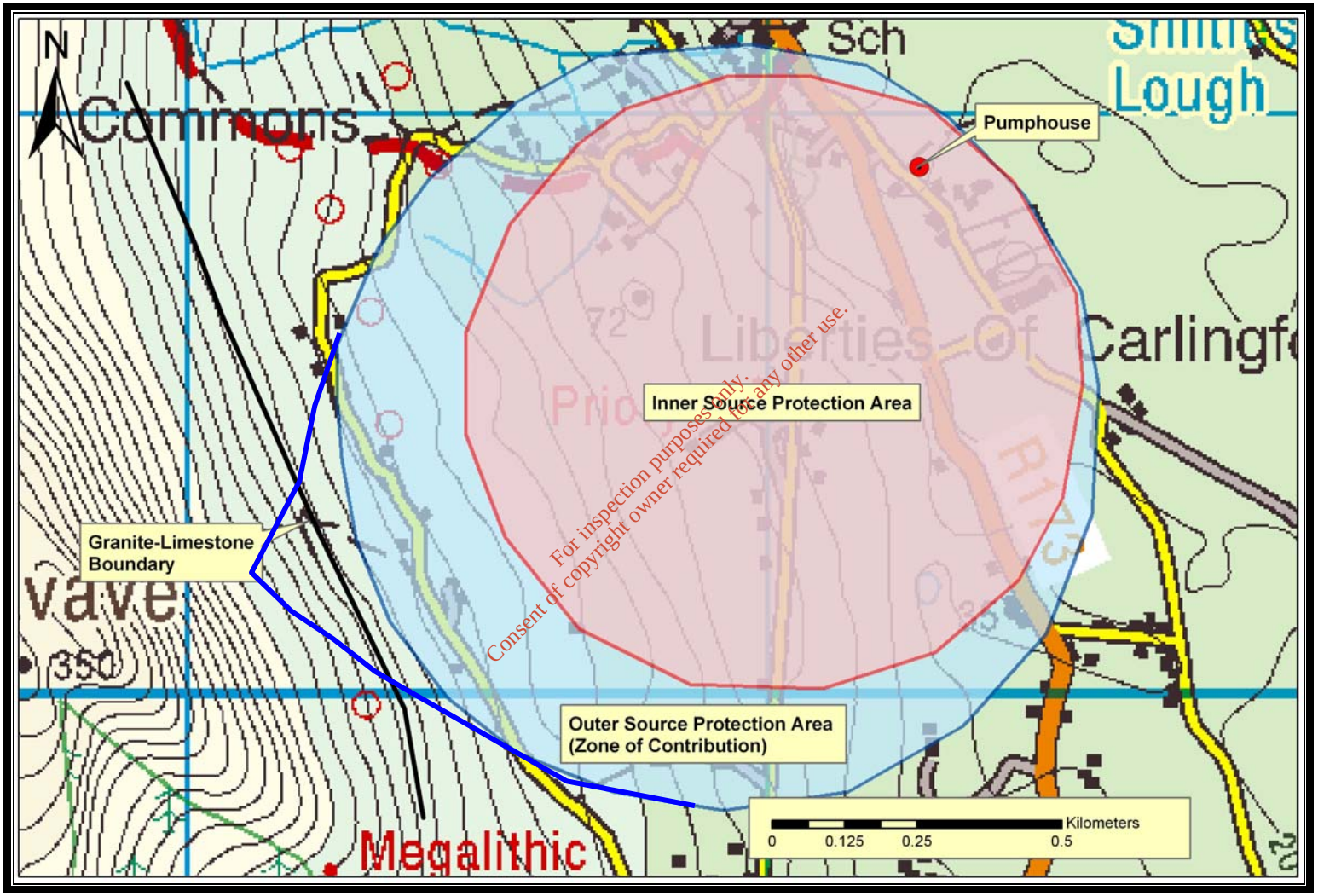


Figure 7: Source Protection Areas for the Carlingford Boreholes Source.

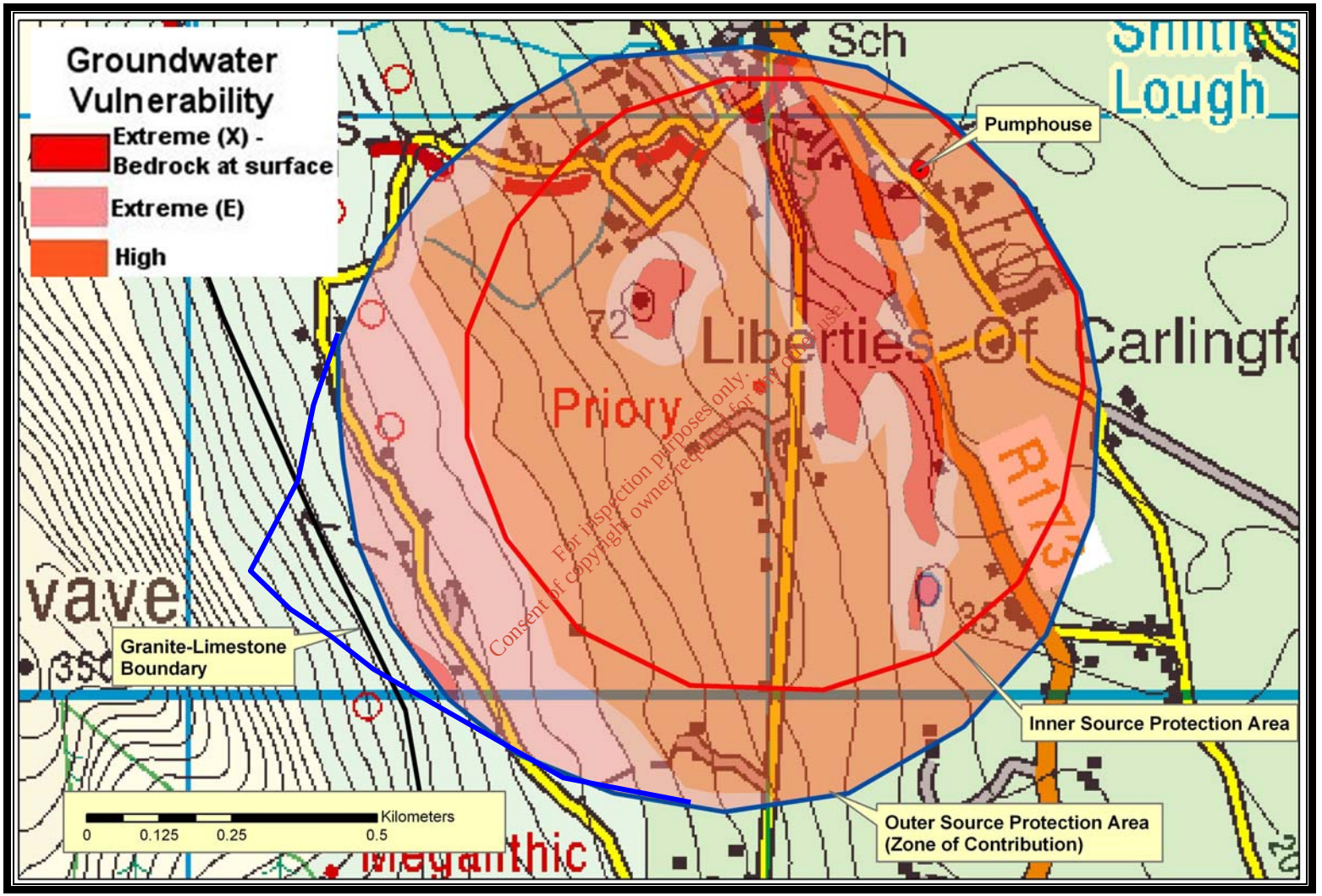


Figure 8: Groundwater Vulnerability within the Source Protection Areas for the Carlingford Boreholes Source.

TO BE ADDED

Figure 9: Source Protection Zones for the Carlingford Boreholes Source.

APPENDIX 2

Trial Pit Logs

Log of Trial Pit: TP1

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 0933

Finish Time: 1103

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 1-9
		TOP SOIL Topsoil capping	0.0 -0.3	
		FILL Infill waste soil, stone, plastic, timber, concrete, brick and car part. Dry construction and demolition waste	0.3	
2			-2.2	
		CLAY Brown silty clay	2.2 -2.5	
		END OF TRIAL PIT	2.5	
4			-5.0	
			5.0	

Date of Excavation: 22 October 2009

Easting: 319342

Northing: 311056

Sheet: 1 of 1

Log of Trial Pit: TP2

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1153

Finish Time: 1240

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 10-24
		TOP SOIL Topsoil capping	0.0	
			-0.9	Slight odour of hydrocarbon
		FILL Infill waste stone, concrete, plastic, glass bottle, cable, rebar, and tyre. Slight odour of hydrocarbon	0.9	
2				Water inflow
		END OF TRIAL PIT	-3.4 / 3.4	
4				

Date of Excavation: 22 October 2009

Easting: 319275

Northing: 311011

Sheet: 1 of 1

Log of Trial Pit: TP3

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1250

Finish Time: 1315

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 25-34
			0.0	
		TOP SOIL Topsoil capping		
			-1.8	
			1.8	
2		***FILL*** Infill waste stone, concrete, plastic, glass bottle		
			-3.0	Water inflow at 2.9m
			3.0	
		END OF TRIAL PIT		
4				

Date of Excavation: 22 October 2009

Easting: 319272

Northing: 311036

Sheet: 1 of 1

Log of Trial Pit: TP4

Project: Carlingford Sewage Works

Site: Carlingford

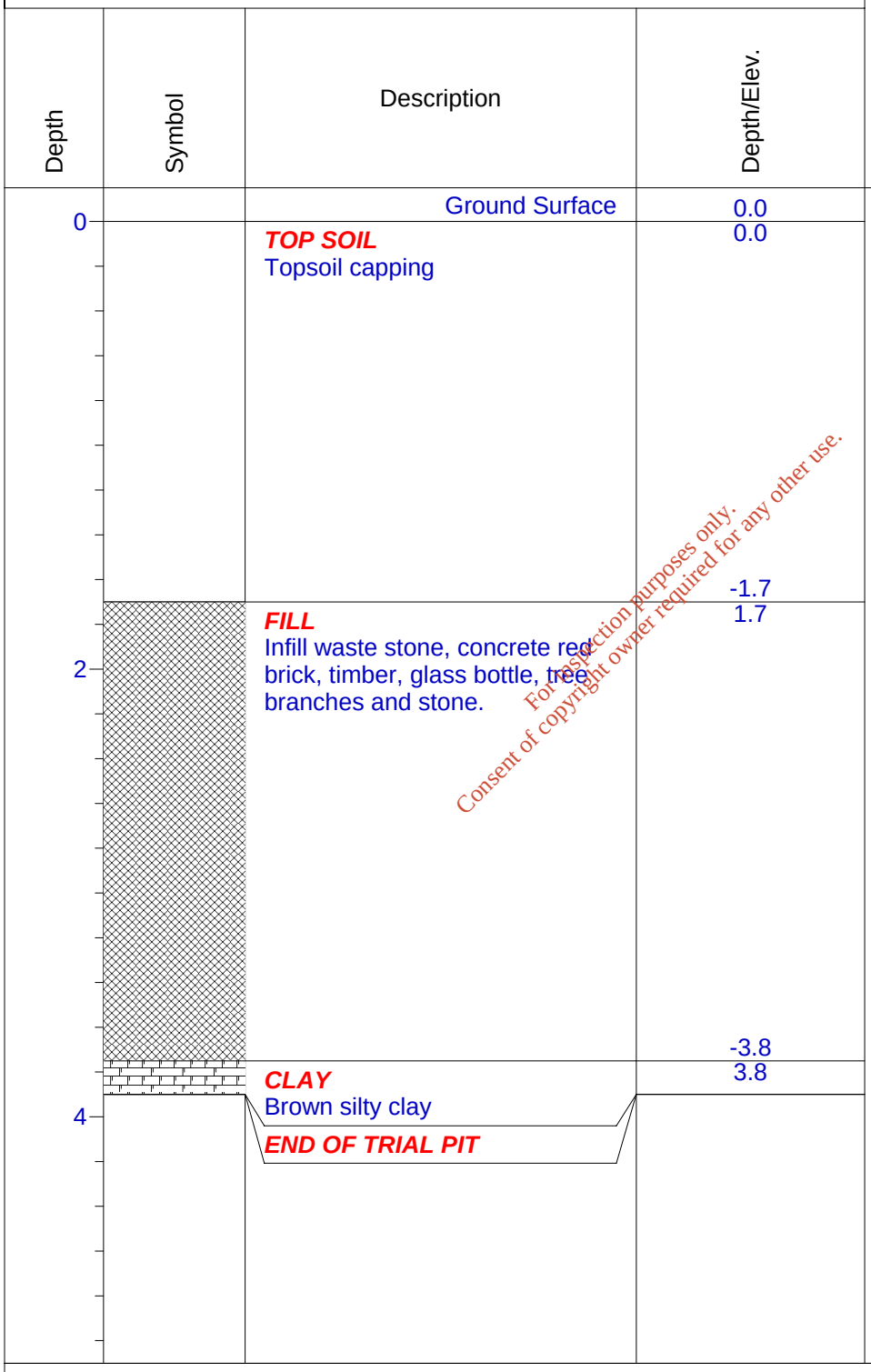
Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1430

Finish Time: 1510

SUBSURFACE PROFILE



Date of Excavation: 22 October 2009

Easting: 319294

Northing: 311030

Sheet: 1 of 1

Log of Trial Pit: TP5

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Declan McMahon

Louth County Council
Environment Section

Start Time: 1520

Finish Time: 1600

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 46-52
		TOP SOIL Topsoil capping	0.0	
			-1.8	
2		***FILL*** Infill waste plastic sheting, soil, stones,rock, bottles, brick,tins, bunrt waste , plastic bags, wood and clothes	1.8	Odour of hydrocarbons at 2.4m
4			-4.3	Water inflow at 4.25
		END OF TRIAL PIT	4.3	

Date of Excavation: 22 October 2009

Easting: 319300

Northing: 311046

Sheet: 1 of 1

Log of Trial Pit: TP6

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Declan McMahon

Louth County Council
Environment Section

Start Time: 1607

Finish Time: 1640

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 55-59
		TOP SOIL Topsoil capping	0.0	
			-1.8	
2		***FILL*** Infill waste plastic sheting, soil, stones,rock, bottles, brick,tins, bunrt waste , plastic bags, wood and clothes	1.8	
4			-4.3	
		END OF TRIAL PIT	4.3	

Date of Excavation: 22 October 2009

Easting: 319321

Northing: 311051

Sheet: 1 of 1

Log of Trial Pit: TP7

Project: Carlingford Sewage Works

Site: Carlingford

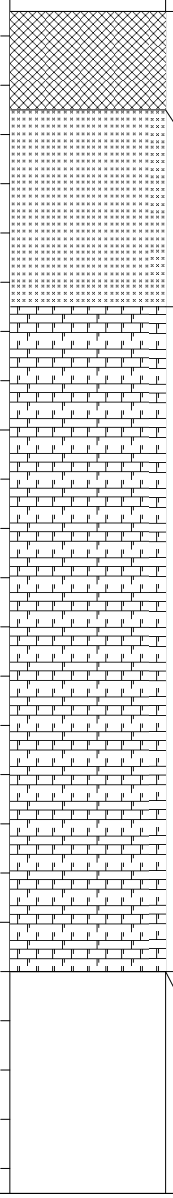
Supervised by: Declan McMahon

Louth County Council
Environment Section

Start Time: 0950

Finish Time: 1055

SUBSURFACE PROFILE



Depth	Symbol	Description	Depth/Elev.	Notes
		Ground Surface	0.0	Photos 60-66
		TOP SOIL Topsoil capping	0.0 -0.3	
		FILL Infill waste brick, plastic, rock, barbed wire, plastic tubs, soil, rags	0.3 -0.7	
		CLAY Brown silty clay	0.7 1.5	
		CLAY Grey silty clay	1.5	
		END OF TRIAL PIT	-4.2 4.2	

Date of Excavation: 23 October 2009

Easting: 319342

Northing: 311056

Sheet: 1 of 1

Log of Trial Pit: TP8

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Rebecca Walsh

Louth County Council
Environment Section

Start Time: 1140

Finish Time: 1210

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
		Ground Surface	0.0	Photos 67-73
0		***TOP SOIL*** Topsoil capping	0.0 -0.3	
		FILL Infill waste plastic bags, stone, glass, plastic, timber, fertiliser bags, tyres, twine, pipe, electrical items)radio), ,etal, childrens bicycle, plastic sheeting, foam, red brick, rags, clothes, plastic tubing	0.3	
2		***CLAY*** Brown silty clay	-2.1 2.1	
		END OF TRIAL PIT		
4			-5.0 5.0	

Date of Excavation: 23 October 2009

Easting: 319349

Northing: 311023

Sheet: 1 of 1

Log of Trial Pit: TP9

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Rebecca Walsh

Louth County Council
Environment Section

Start Time: 1216

Finish Time: 1240

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 74-80
		TOP SOIL Topsoil capping	0.0 -0.3	
		FILL Infill waste plastic bags, stone, glass, plastic, timber, fertiliser bags, tyres, twine, pipe, bone,metal, childrens bicycle, plastic sheeting, foam, red brick, rags, clothes, plastic tubing	0.3	
2			-2.3	
		CLAY Brown silty clay	2.3	
		END OF TRIAL PIT		
4			-5.0	
			5.0	

Date of Excavation: 23 October 2009

Easting: 319356

Northing: 310995

Sheet: 1 of 1

Log of Trial Pit: TP10

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Rebecca Walsh

Louth County Council
Environment Section

Start Time: 1242

Finish Time: 1312

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 81-87
		TOP SOIL Topsoil capping	0.0	
			-0.5	
		FILL Infill waste plastic bags, plastic sheeting, tyre, glassbottles, fertiliser bag, metal,rope, stone, rags, clothes, timber, twine, plastic strapping, burnt waste, canvas coal sacks, plastic containers and plastic bottles.	0.5	
2			-2.5	
		CLAY Brown silty clay	2.5	
			-2.8	
		END OF TRIAL PIT	2.8	
4			-5.0	
			5.0	

Date of Excavation: 23 October 2009

Easting: 319344

Northing: 310992

Sheet: 1 of 1

Log of Trial Pit: TP11

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Rebecca Walsh

Louth County Council
Environment Section

Start Time: 1410

Finish Time: 1505

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 81-87
		TOP SOIL Topsoil capping	0.0 -0.4	
		FILL Infill waste plastic bags, plastic sheeting, tyre, glassbottles, fertiliser bag, metal,rope, stone, rags, clothes, timber, twine, plastic sacks, plastic containers and plastic bottles.	0.4	
2				Oily odour noted from waste
			-2.9	
		CLAY Brown silty clay	2.9 -3.4	
		FILL Infill timber rags, wire, metal,concrete, foam, shoes, rags, clothes and stone	3.4	
4			-4.2	
		CLAY Brown silty cla	4.2	
		END OF TRIAL PIT	-5.0	
			5.0	

Date of Excavation: 23 October 2009

Easting: 319336

Northing: 311019

Sheet: 1 of 1

Log of Trial Pit: TP12

Project: Carlingford Sewage Work

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1045

Finish Time: 1115

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
		Ground Surface	0.0	Photos 1-6
0		***TOPSOIL CAPPING*** Topsoil and capping	0.0 -0.3	
		FILL Infill soil,stone, rag, plastic, burnt material, tryre rim, concrete axle metal and timber. Consistent with dry Construction and demolition waste	0.3	
2				
4		***END OF TRIAL PIT***	-4.3 4.3	

Date of Excavation: 14th December 2009

Easting: 319260

Northing: 311106

Sheet: 1 of 1

Log of Trial Pit: TP13

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1135

Finish Time: 1900

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	
			-0.5	Photos 9-17
		FILL Infill soil stone concrete plastic metal and rags. timber, plastic bottle.	0.5	
2		***END OF TRIAL PIT***	-2.0 2.0	
4				

Date of Excavation: 14 December 2009

Easting: 319280

Northing: 311103

Sheet: 1 of 1

Log of Trial Pit: TP14

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1000

Finish Time: 11

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
		TOP SOIL	0.0	No odour
		Topsoil capping	-0.3	
		FILL	0.3	
		Infill soil, stone, concrete, plastic, tyre, metal.		Photos 19-24
2				
				Water visible at 2.9m
			-3.5	
		END OF TRIAL PIT	3.5	
4				

Date of Excavation: 14 December 2009

Easting: 319280

Northing: 311103

Sheet: 1 of 1

Log of Trial Pit: TP16

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1135

Finish Time: 1150

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	
			-0.5	Photos 27-30
		END OF TRIAL PIT	0.5	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319248

Northing: 311136

Sheet: 1 of 1

Log of Trial Pit: TP17

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1150

Finish Time: 1210

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	
			-0.5	Photos 33-35
		FILL Soil, plastic, metal, concrete, brick, tyre	0.5	
2		***END OF TRIAL PIT***	-2.0 2.0	
4				

Date of Excavation: 14 December 2009

Easting: 319254

Northing: 311039

Sheet: 1 of 1

Log of Trial Pit: TP18

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1225

Finish Time: 1235

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
		TOP SOIL	0.0	No odour
		Topsoil capping	-0.3	
		FILL	0.3	
		Soil, plastic, metal, concrete, brick, tyre	-0.6	Photos 33-35
			0.6	
		END OF TRIAL PIT		
2				
4				

Date of Excavation: 14 December 2009

Easting: 319257

Northing: 311008

Sheet: 1 of 1

Log of Trial Pit: TP19

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1240

Finish Time: 1245

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
		TOP SOIL Topsoil capping	0.0	No odour
			-0.5	Photos 38-39
		END OF TRIAL PIT	0.5	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319253

Northing: 310943

Sheet: 1 of 1

Log of Trial Pit: TP20

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1250

Finish Time: 1255

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
			0.0	No odour
		TOP SOIL Topsoil capping		
		FILL Soil, concrete rubble, brick,plastic	-0.5	Photos 40-42
			0.5	
		END OF TRIAL PIT		
2				
4			-5.0	
			5.0	

Date of Excavation: 14 December 2009

Easting: 319253

Northing: 310943

Sheet: 1 of 1

Log of Trial Pit: TP21

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1400

Finish Time: 1411

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	Photos 43-44
			-0.8	
		FILL Soil, concrete rubble, brick,plastic	0.8	
			1.5	
		END OF TRIAL PIT	1.5	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319276

Northing: 311015

Sheet: 1 of 1

Log of Trial Pit: TP22

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1415

Finish Time: 1422

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	Photos 45-47
		FILL Soil, concrete rubble, brick,plastic	1.5	
2		***END OF TRIAL PIT***	1.5	
4				

Date of Excavation: 14 December 2009

Easting: 319275

Northing: 311045

Sheet: 1 of 1

Log of Trial Pit: TP23

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1427

Finish Time: 1435

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOP SOIL Topsoil capping	0.0	Photos 48-51
			-1.0	
		FILL Soil, concrete rubble, brick,plastic	1.0	
2		***END OF TRIAL PIT***	-2.0 2.0	
4				

Date of Excavation: 14 December 2009

Easting: 319300

Northing: 311035

Sheet: 1 of 1

Log of Trial Pit: TP24

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1438

Finish Time: 1443

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
		Ground Surface	0.0	
0			0.0	No odour
		TOP SOIL Topsoil capping		Photos 1-9
			-0.9	
		FILL Soil, concrete rubble, brick,plastic	0.9	
2		***END OF TRIAL PIT***	-2.0 2.0	
4				

Date of Excavation: 14 December 2009

Easting: 319301

Northing: 311052

Sheet: 1 of 1

Log of Trial Pit: TP25

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1448

Finish Time: 1450

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
		Ground Surface	0.0	
0			0.0	No odour
		TOP SOIL Topsoil capping	-0.3	
			0.3	
		FILL Soil, concrete rubble, brick,plastic		Photos 10-24
2		***END OF TRIAL PIT***	-2.0 2.0	
4				

Date of Excavation: 14 December 2009

Easting: 319324

Northing: 311057

Sheet: 1 of 1

Log of Trial Pit: TP26

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1454

Finish Time: 1458

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
			0.0	No odour
		FILL Soil, concrete rubble, brick,plastic		
			-0.3	
		END OF TRIAL PIT	0.3	
				Photos 25-34

Date of Excavation: 14 December 2009

Easting: 319348

Northing: 311064

Sheet: 1 of 1

Log of Trial Pit: TP27

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1500

Finish Time: 1503

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
		FILL Soil, concrete rubble, brick,plastic	0.0	No odour
			-0.3	
		END OF TRIAL PIT	0.3	
			-0.3	
			0.3	

Photos 35-44

Date of Excavation: 14 December 2009

Easting: 319353

Northing: 31044

Sheet: 1 of 1

Log of Trial Pit: TP28

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1505

Finish Time: 1515

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
			0.0	No odour
		FILL Soil, concrete rubble, brick,plastic		
			-0.4	
		END OF TRIAL PIT	0.4	
				Photos 35-44

Date of Excavation: 14 December 2009

Easting: 319357

Northing: 311028

Sheet: 1 of 1

Log of Trial Pit: TP29

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1523

Finish Time: 1530

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOPSOIL Topsoil and Capping	0.0	
			-0.6	Photos 10-24
		FILL Soil, concrete rubble, brick,plastic	0.6	
			-1.0	
		END OF TRIAL PIT	1.0	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319362

Northing: 310993

Sheet: 1 of 1

Log of Trial Pit: TP30

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1531

Finish Time: 1535

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOPSOIL Topsoil and Capping	0.0	
			-0.6	Photos 25-34
		FILL Soil, concrete rubble, brick,plastic	0.6	
			-1.0	
		END OF TRIAL PIT	1.0	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319346

Northing: 310989

Sheet: 1 of 1

Log of Trial Pit: TP31

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1538

Finish Time: 1540

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	
		TOPSOIL Topsoil and Capping	0.0 -0.4	
		FILL Soil, concrete rubble, brick,plastic	0.4 -1.0	Photos 35-44
		END OF TRIAL PIT	1.0	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319341

Northing: 310014

Sheet: 1 of 1

Log of Trial Pit: TP32

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1540

Finish Time: 1543

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	No odour
		TOPSOIL Topsoil and Capping	0.0 -0.3	
		FILL Soil, concrete, rubble, brick,plastic	0.3	Photos 1-9
			-1.0	
		END OF TRIAL PIT	1.0	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319329

Northing: 311030

Sheet: 1 of 1

Log of Trial Pit: TP33

Project: Carlingford Sewage Works

Site: Carlingford

Supervised by: Pamela Dagg

Louth County Council
Environment Section

Start Time: 1547

Finish Time: 1550

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Notes
0		Ground Surface	0.0	Photos 10-24
		TOPSOIL Topsoil and Capping	0.0	
			-0.5	
		FILL Soil, concrete, rubble, brick,plastic	0.5	
			-1.0	
		END OF TRIAL PIT	1.0	
2				
4				

Date of Excavation: 14 December 2009

Easting: 319342

Northing: 311037

Sheet: 1 of 1

APPENDIX 3

Laboratory Reports

EURO environmental services

Environmental Science & Management
Water,Soil & Air Testing

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland

Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/081/01
		Date of Receipt	23/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Collected by Euro
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford Groundwater borehole 23/10/09	*Sample Type*	Groundwater

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Ground Water)	102	Colorimetry	48	mg/L CaCO3	UKAS
Ammonia (Ground Water)	114	Colorimetry	1.11	mg/L as N	UKAS
Arsenic (Ground Water)	177	ICPMS	<0.1	ug/L	UKAS
Atrazine	191	HPLC	<0.01	ug/L	
Boron (Ground Water)	177	ICPMS	112.9	ug/L	UKAS
Cadmium (Ground Water)	177	ICPMS	<0.09	ug/L	UKAS
Calcium	184	ICPMS	12.10	mg/L	
Chloride (Ground Water)	100	Colorimetry	17.55	mg/L	UKAS
Chromium (Ground Water)	177	ICPMS	2.7	ug/L	UKAS
Coliforms (Faecal)	140	Filtration/ Incubation 44C/ 24	0	no/ 100ml	
Coliforms (Total)	140	Filtration/ Incubation 37C/ 24	3	no/ 100ml	
Conductivity (Ground Water)	112	Electrometry	162	uscm -1@25C	UKAS
Copper (Ground Water)	177	ICPMS	1.7	ug/L	UKAS
Cyanide	138	Colorimetry	<5	ug/L	
Dichloromethane	154	GCMS	<1	ug/L	
Fluoride (Ground Water)	115	Colorimetry	<0.02	mg/L	UKAS
Iron (Ground Water)	177	ICPMS	1435	ug/L	
Lead (Ground Water)	177	ICPMS	1.2	ug/L	UKAS
m-& p-Xylene	179	GCMS	<0.73	ug/L	
Magnesium	184	ICPMS	0.60	mg/L	
Manganese (Ground Water)	177	ICPMS	228.1	ug/L	UKAS
Mercury	178	ICPMS	<0.03	ug/L	
Nickel (Ground Water)	177	ICPMS	1.6	ug/L	UKAS
Nitrogen (Total Oxidised) (Ground	151	Colorimetry	<0.28	mg/L as N	UKAS
o-Xylene	179	GCMS	<0.35	ug/L	

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

Acc. : Accredited Parameters by ISO 17025:2005

All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of EURO environmental services
Results contained in this report relate only to the samples tested

EURO environmental services

Environmental Science & Management
Water,Soil & Air Testing

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/081/01
		Date of Receipt	23/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Collected by Euro
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford Groundwater borehole 23/10/09	*Sample Type*	Groundwater

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Phosphate (Ortho) Ground Water	117	Colorimetry	0.009	mg/L as P	UKAS
Potassium	184	ICPMS	1.31	mg/L	
Simazine	191	HPLC	<0.01	ug/L	
Sodium	184	ICPMS	7.64	mg/L	
Solids (Total Dissolved)	105	Filtration/ Evaporation @ 180	19	mg/L	
Sulphate	119	Colorimetry	<1.39	mg/L as SO4	
Toluene	179	GCMS	<0.28	ug/L	
Total Organic Carbon	316	TOC analyser (NPOC)	16.00	mg/L	
Tributyltin*	0	GCMS	<0.02	ug/L as Sn	
Xylene (Total)	179	GCMS	<1	ug/L	
Zinc (Ground Water)	177	ICPMS	1.4	ug/L	UKAS

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

Acc. : Accredited Parameters by ISO 17025:2005

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EURO environmental services

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Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/081/02
		Date of Receipt	23/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Collected by Euro
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford Trial Hole 2 22/10/09	*Sample Type*	Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia	114	Colorimetry	49.31	mg/L as N	
Arsenic	177	ICPMS	2.7	ug/L	
Atrazine	191	HPLC	<0.01	ug/L	
BOD	113	Electrometry	20	mg/L	
Boron	177	ICPMS	317.5	ug/L	
Cadmium	177	ICPMS	<0.09	ug/L	
Calcium	184	ICPMS	230.20	mg/L	
Chloride	100	Colorimetry	38.36	mg/L	
Chromium	177	ICPMS	7.1	ug/L	
COD	107	Colorimetry	114	mg/L	
Copper	177	ICPMS	1.2	ug/L	
Cyanide	138	Colorimetry	<5	ug/L	
Dichloromethane	154	GCMS	<1	ug/L	
Fluoride	115	Colorimetry	0.40	mg/L	
Iron (Total)	177	ICPMS	21820.0	ug/L	
Lead	177	ICPMS	1.8	ug/L	
Magnesium	184	ICPMS	36.96	mg/L	
Manganese	177	ICPMS	2746.0	ug/L	
Mercury	178	ICPMS	<0.03	ug/L	
Nickel	177	ICPMS	3.5	ug/L	
Nitrogen (Total Oxidised)	151	Colorimetry	<0.03	mg/L as N	
Phosphate (Ortho)	117	Colorimetry	0.094	mg/L as P	
Potassium	184	ICPMS	59.70	mg/L	
Simazine	191	HPLC	<0.01	ug/L	
Sodium	184	ICPMS	24.12	mg/L	

Web Certificate ***Date : 20/11/2009***

Acc. : Accredited Parameters by ISO 17025:2005

All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of EURO environmental services
Results contained in this report relate only to the samples tested

EURO environmental services

Environmental Science & Management
Water,Soil & Air Testing

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Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/081/02
		Date of Receipt	23/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Collected by Euro
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford Trial Hole 2 22/10/09	*Sample Type*	Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Solids (Total Suspended)	106	Filtration/ Drying @ 104C	162	mg/L	
Sulphate	119	Colorimetry	<1.39	mg/L as SO4	
Toluene	179	GCMS	<0.28	ug/L	
Tributyltin*	0	GCMS	<0.30	ug/L as Sn	
Xylene (Total)	179	GCMS	<1	ug/L	
Zinc	177	ICPMS	<4.6	ug/L	

Web Certificate ***Date : 20/11/2009***

Acc. : Accredited Parameters by ISO 17025:2005

All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of EURO environmental services
Results contained in this report relate only to the samples tested

Fitz scientific
Monitoring and Testing Services

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.fitzsci.ie
email: info@fitzsci.ie

A copy of this certificate is available on www.fitzsci.ie

Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/083/02**
		Date of Receipt	**15/12/2009**
		Sampled On	**15/12/2009**
		Date Testing Commenced	**15/12/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO		***Date of Report***	**29/01/2013**
Customer Ref	**Carlingford SWTP - Trial Hole 13 14/12/09**	***Sample Type***	**Groundwater**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Ground Water)	114	Colorimetry	3.86	mg/L as N	UKAS
COD (Ground Water)	107	Colorimetry	29	mg/L	UKAS
Conductivity (Ground Water)	112	Electrometry	710	uscm -1@25C	UKAS
pH (Ground Water)	110	Electrometry	7	pH Units	UKAS
Phosphate (Total) Ground Water	166	Colorimetry	0.172	mg/L as P	UKAS

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU Drinking water Regulations (SI 278 2007)
All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of Fitz Scientific
Results contained in this report relate only to the samples tested
**The analytical result for this parameter may not be reflective of the concentration present at the time of sampling. The maximum recommended preservation time for this parameter has been exceeded.

Fitz scientific
Monitoring and Testing Services

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.fitzsci.ie
email: info@fitzsci.ie

A copy of this certificate is available on www.fitzsci.ie

Customer	**Pamela Dagg**	***Lab Report Ref. No.***	**2710/083/03**
	Louth Co. Co.	***Date of Receipt***	**15/12/2009**
	Enforcement Section	***Sampled On***	**15/12/2009**
	Louth County Council	***Date Testing Commenced***	**15/12/2009**
	Millenium Centre , Dundalk	***Received or Collected***	**Delivered by Customer**
	County Louth	***Condition on Receipt***	**Acceptable**
Customer PO		***Date of Report***	**29/01/2013**
Customer Ref	**Carlingford SWTP - Trial Hole 14 15/12/09**	***Sample Type***	**Groundwater**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Ground Water)	114	Colorimetry	28.53	mg/L as N	UKAS
Arsenic (Ground Water)	177	ICPMS	8.5	ug/L	UKAS
Atrazine	191	HPLC	<0.01	ug/L	
BOD (Ground Water)	113	Electrometry	<2	mg/L	UKAS
Boron (Ground Water)	177	ICPMS	440.5	ug/L	UKAS
Cadmium (Ground Water)	177	ICPMS	0.8	ug/L	UKAS
Calcium	184	ICPMS	176.90	mg/L	
Chloride (Ground Water)	100	Colorimetry	32.54	mg/L	UKAS
Chromium (Ground Water)	177	ICPMS	11.2	ug/L	UKAS
COD (Ground Water)	107	Colorimetry	246	mg/L	UKAS
Copper (Ground Water)	177	ICPMS	19.6	ug/L	UKAS
Cyanide	138	Colorimetry	<5	ug/L	
Dichloromethane	154	GCMS	<1	ug/L	
Fluoride (Ground Water)	115	Colorimetry	0.44	mg/L	UKAS
Iron (Ground Water)	177	ICPMS	45810	ug/L	UKAS
Lead (Ground Water)	177	ICPMS	46.4	ug/L	UKAS
m-& p-Xylene	179	GCMS	<0.73	ug/L	
Magnesium	184	ICPMS	31.34	mg/L	
Manganese (Ground Water)	177	ICPMS	3046	ug/L	UKAS
Mercury	178	ICPMS	<0.03	ug/L	
Nickel (Ground Water)	177	ICPMS	13.1	ug/L	UKAS
Nitrogen (Total Oxidised) (Ground Wat	151	Colorimetry	<0.28	mg/L as N	UKAS
o-Xylene	179	GCMS	<0.35	ug/L	
Phosphate (Ortho) Ground Water	117	Colorimetry	0.062	mg/L as P	UKAS
Potassium	184	ICPMS	43.82	mg/L	

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU Drinking water Regulations (SI 278 2007)
All organic results are analysed as received and all results are corrected for dry weight at 104 C

Results contained in this report relate only to the samples tested
**The analytical result for this parameter may not be reflective of the concentration present at the time of sampling. The maximum recommended preservation time for this parameter has been exceeded.

Fitz scientific
Monitoring and Testing Services

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.fitzsci.ie
email: info@fitzsci.ie

A copy of this certificate is available on www.fitzsci.ie

Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/083/03**
		Date of Receipt	**15/12/2009**
		Sampled On	**15/12/2009**
		Date Testing Commenced	**15/12/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO		***Date of Report***	**29/01/2013**
Customer Ref	**Carlingford SWTP - Trial Hole 14 15/12/09**	***Sample Type***	**Groundwater**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Simazine	191	HPLC	<0.01	ug/L	
Sodium	184	ICPMS	21.99	mg/L	
Solids (Total Suspended)	106	Filtration/ Drying @ 104C	4335	mg/L	
Sulphate	119	Colorimetry	<1.39	mg/L as SO4	
Toluene	179	GCMS	<0.28	ug/L	
Tributyltin	0	GCMS	<0.03	ug/L as Sn	
Xylene (Total)	179	GCMS	<1	ug/L	
Zinc (Ground Water)	177	ICPMS	78.9	ug/L	UKAS

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU Drinking water Regulations (SI 278 2007)
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* Subcontracted

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Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/083/01**
		Date of Receipt	**15/12/2009**
		Sampled On	**15/12/2009**
		Date Testing Commenced	**15/12/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO		***Date of Report***	**29/01/2013**
Customer Ref	**Carlingford SWTP - Stream 14/12/09**	***Sample Type***	**Surface Water**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.49	mg/L as N	UKAS
BOD (Surface Water)	113	Electrometry	<2	mg/L	UKAS
COD (Surface Water)	107	Colorimetry	28	mg/L	UKAS
Conductivity (Surface Water)	112	Electrometry	576	uscm -1@25C	UKAS
pH (Surface Water)	110	Electrometry	7.4	pH Units	UKAS
Phosphate (Total) Surface Water	166	Colorimetry	0.188	mg/L as P	UKAS

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

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Jones Environmental Laboratory

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

AMC
3C Heron Wharf
Heron Road
Belfast
BT3 9LE

UKAS TESTING
No.4225

Attention :	Noeleen O'Higgins
Date :	31st January 2011
Your reference :	Carlingford
Our reference :	Test Report 11/141
Location :	Carlingford
Date samples received :	14th January 2011
Status :	Final Report
Issue :	1

Two samples were received for analysis on 14th January 2011 which was completed on 31st January 2011. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced.
All interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

J W Farrell- Jones CChem FRSC
Chartered Chemist

Jones Environmental Laboratory

Client Name:	AMC	**Report :**	**Liquids**
Reference:	Carlingford		
Location:	Carlingford		
Contact:	Noeleen O'Higgins	**Liquids/products:**	V=40ml vial, G=glass bottle, P=plastic bottle
JE Job No.:	11/141		$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

J E Sample No.	1-2	3-4	LOD	Units	Method No.
Sample ID	Upgradient Water	Downgradient Water			
Depth	-	-			
COC No / misc					
Containers	H P	H P			
Sample Date	12/01/11	12/01/11			
Sample Type	Water	Water			
Batch Number	1	1			
Date of Receipt	14/01/11	14/01/11			
pH#	8.00	8.37	<0.01	pH units	TM073
Electrical Conductivity# @25°C	386	405	<100	µS/cm	TM28/PM11
Sulphate#	9.04	10.93	<0.05	mg/l	TM038W
Chloride#	14.9	19.6	<0.3	mg/l	TM038W
Amm N/Tot Ammonia as N#	0.07	0.06	<0.03	mg/l	TM038W
Phosphorous - total	34	82	<5	µg/l	TM 030W
Total Oxidised Nitrogen as N#	1.10	1.34	<0.05	mg/l	TM038W
Total Suspended Solids	<10	<10	<10	mg/l	TM037W
Total Alkalinity as CaCO3#	159	178	<1	mg/l	TM075W
BOD settled	<1	<1	<1	mg/l	TM058W
COD	<7	<7	<7	mg/l	TM057W
Arsenic - dissolved #	<2.5	<2.5	<2.5	µg/l	TM 030W
Boron - dissolved	20	33	<12	µg/l	TM 030W
Cadmium - dissolved #	<0.5	<0.5	<0.5	µg/l	TM 030W
Total Chromium - dissolved #	<1.5	<1.5	<1.5	µg/l	TM 030W
Copper - dissolved #	<7	<7	<7	µg/l	TM 030W
Mercury - dissolved #	<1	<1	<1	µg/l	TM 030W
Nickel - dissolved #	<2	<2	<2	µg/l	TM 030W
Lead - dissolved #	6	6	<5	µg/l	TM 030W
Zinc - dissolved #	38	43	<3	µg/l	TM 030W
Total Iron - dissolved #	74	75	<20	µg/l	TM 030W
Manganese - dissolved #	2	15	<2	µg/l	TM 030W
Antimony - dissolved #	<2	<2	<2	µg/l	TM 030W
Calcium - dissolved#	69.3	71.0	<0.2	mg/l	TM 030W
Magnesium - dissolved#	3.9	4.8	<0.1	mg/l	TM 030W
Potassium - dissolved#	1.3	2.6	<0.1	mg/l	TM 030W
Sodium - dissolved#	10.1	13.9	<0.1	mg/l	TM 030W

Please see attached notes for all abbreviations and acronyms

Jones Environmental Laboratory

Client Name:	AMC	**Report :**	**Solids**
Reference:	Carlingford		
Location:	Carlingford		
Contact:	Noeleen O'Higgins	**Liquids/products:**	V=40ml vial, G=glass bottle, P=plastic bottle
JE Job No.:	11/141		$H=H_2SO_4$, Z=ZnAc, N=NaOH, HN=$HN0_3$

J E Sample No.	5-6	7-8									LOD	Units	Method No.
Sample ID	Upgradient Sediment	Downgradient Sediment											
Depth	-	-											
COC No / misc													
Containers	H P	H P											
Sample Date	12/01/11	12/01/11											
Sample Type	Sed	Sed											
Batch Number	1	1											
Date of Receipt	14/01/11	14/01/11											
pH #	7.42	7.47									<0.01	pH units	TM73
Chloride - soluble	116	205									<2	mg/kg	TM038
Sulphate - soluble 2:1 extract#	0.062	0.340									<0.015	g/l	TM038
Electrical Conductivity	1500	1475									<100	µS/cm	TM28/PM11
Ammoniacal Nitrogen as N	12.2	3.1									<0.4	mg/kg	TM038
Total Oxidised Nitrogen as N#	0.07	0.13									<0.05	mg/kg	TM038
Total Alkalinity as CaCO3#	16596	701									<1	mg/kg	TM075
Arsenic #	6.0	12.6									<0.5	mg/kg	TM030
Cadmium #	0.3	0.6									<0.1	mg/kg	TM030
Chromium #	36.3	57.9									<0.5	mg/kg	TM030
Copper #	32	44									<1	mg/kg	TM030
Mercury #	0.1	0.2									<0.1	mg/kg	TM030
Nickel #	36.8	51.9									<0.7	mg/kg	TM030
Lead #	24	54									<5	mg/kg	TM030
Zinc #	118	157									<5	mg/kg	TM030
Water Soluble Boron #	1.9	5.2									<0.1	mg/kg	TM074
Antimony	<1	<1									<1	mg/kg	TM030
Calcium	<500	<500									<500	mg/kg	TM030
Iron	26900	39460									<20	mg/kg	TM030
Magnesium	<25	<25									<25	mg/kg	TM030
Manganese #	416	456									<1	mg/kg	TM030
Phosphorous	890	866									<10	mg/kg	TM030
Sodium	10	14									<5	mg/kg	TM030
Potassium	<5	<5									<5	mg/kg	TM030

Please see attached notes for all abbreviations and acronyms

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

SOILS

Please note we are only MCERTS accredited for sand, loam and clay and any other matrix is outside our scope of accreditation.
Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. Your final report will reflect this, with non-MCERTS results on separate pages.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary. If we are instructed to keep samples, a storage charge of £1 (1.5 Euros) per sample per month will be applied until we are asked to dispose of them.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Asbestos screens where requested will be undertaken by a UKAS accredited laboratory.

WATERS

Please note we are not a Drinking Water Inspectorate (DWI) Approved Laboratory . It is important that detection limits are carefully considered when requesting water analysis.

UKAS accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples. All samples are treated as groundwaters and analysis performed on settled samples unless we are instructed otherwise.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any analysis that may be compromised highlighted on your schedule/ report by the use of a symbol.

The use of any of the following symbols indicates that the sample was deviating and the test result may be unreliable:

$ sample temperature on receipt considered inappropriate for analysis requested
^ samples exceeding recomended holding times
& samples received in inappropriate containers (e.g. volatile samples not submitted in VOC jars/vials)
~ no sampling date given, unable to confirm if samples are with acceptable holding times

ABBREVIATIONS and ACRONYMS USED

- UKAS accredited
M - MCERTS accredited
NAD - No Asbestos Detected
ND - None Detected (usually refers to VOC and/SVOC TICs)
SS - Calibrated against a single substance
* - analysis subcontracted to a Jones Environmental approved laboratory.
W - Results expressed on as received basis
+ Failed AQC results should be considered as indicative only and are not accredited.
++ Result outside calibration range, may be possible to re-run with higher detection limits

EURO environmental services

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Water,Soil & Air Testing

Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland

Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	**Pamela Dagg** **Louth Co Co** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/080/01**
		Date of Receipt	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**20/11/2009**
Customer Ref	**Carlingford STP Upstream 22/10/09**	***Sample Type***	**Surface Water**

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Surface Water)	102	Colorimetry	180	mg/L CaCO3	UKAS
Ammonia (Surface Water)	114	Colorimetry	0.069	mg/L as N	UKAS
Arsenic (Surface Water)	177	ICPMS	0.2	ug/L	UKAS
Atrazine	191	HPLC	<0.01	ug/L	
BOD (Surface Water)	113	Electrometry	<2	mg/L	UKAS
Boron (Surface Water)	177	ICPMS	272.8	ug/L	UKAS
Cadmium (Surface Water)	177	ICPMS	0.2	ug/L	UKAS
Calcium	184	ICPMS	48.47	mg/L	
Chloride (Surface Water)	100	Colorimetry	13.51	mg/L	UKAS
Chromium (Surface Water)	177	ICPMS	1.3	ug/L	UKAS
COD (Surface Water)	107	Colorimetry	<5	mg/L	UKAS
Conductivity (Surface Water)	112	Electrometry	394	uscm -1@25C	UKAS
Copper (Surface Water)	177	ICPMS	1.9	ug/L	UKAS
Dichloromethane	154	GCMS	<1	ug/L	
Fluoride (Surface Water)	115	Colorimetry	0.11	mg/L	UKAS
Iron (Surfacewater)	177	ICPMS	235.4	ug/L	UKAS
Lead (Surface Water)	177	ICPMS	3.3	ug/L	UKAS
m-& p-Xylene	179	GCMS	<0.73	ug/L	
Magnesium	184	ICPMS	1.76	mg/L	
Manganese (Surface Water)	177	ICPMS	5.1	ug/L	UKAS
Mercury	178	ICPMS	<0.03	ug/L	
Nickel (Surface Water)	177	ICPMS	1.3	ug/L	UKAS
Nitrogen (Total Oxidised) (Surface	151	Colorimetry	2.17	mg/L as N	UKAS
o-Xylene	179	GCMS	<0.35	ug/L	
pH (Surface Water)	110	Electrometry	8	pH Units	UKAS

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

Acc. : Accredited Parameters by ISO 17025:2005

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Ireland
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Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/080/01
		Date of Receipt	22/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford STP Upstream 22/10/09	*Sample Type*	Surface Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Phosphate (Ortho) Surface Water	117	Colorimetry	<0.006	mg/L as P	UKAS
Potassium	184	ICPMS	1.37	mg/L	
Simazine	191	HPLC	<0.01	ug/L	
Sodium	184	ICPMS	7.69	mg/L	
Solids (Total Suspended)	106	Filtration/ Drying @ 104C	7	mg/L	
Sulphate	119	Colorimetry	11.92	mg/L as SO4	
Toluene	179	GCMS	<0.28	ug/L	
Total Cyanide	0	Spectrometry	<0.05	mg/L	
Tributyltin	0	GCMS	<0.02	ug/L as Sn	
Xylene (Total)	179	GCMS	<1	ug/L	
Zinc (Surface Water)	177	ICPMS	7.5	ug/L	UKAS

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

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Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/080/02
		Date of Receipt	22/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford STP Downstream 22/10/09	*Sample Type*	Surface Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Surface Water)	102	Colorimetry	198	mg/L CaCO3	UKAS
Ammonia (Surface Water)	114	Colorimetry	0.039	mg/L as N	UKAS
Arsenic (Surface Water)	177	ICPMS	0.5	ug/L	UKAS
Atrazine	191	HPLC	<0.01	ug/L	
BOD (Surface Water)	113	Electrometry	<2	mg/L	UKAS
Boron (Surface Water)	177	ICPMS	200.2	ug/L	UKAS
Cadmium (Surface Water)	177	ICPMS	0.1	ug/L	UKAS
Calcium	184	ICPMS	53.96	mg/L	
Chloride (Surface Water)	100	Colorimetry	15.39	mg/L	UKAS
Chromium (Surface Water)	177	ICPMS	0.9	ug/L	UKAS
COD (Surface Water)	107	Colorimetry	<5	mg/L	UKAS
Conductivity (Surface Water)	112	Electrometry	437	uscm -1@25C	UKAS
Copper (Surface Water)	177	ICPMS	2.2	ug/L	UKAS
Dichloromethane	154	GCMS	<1	ug/L	
Fluoride (Surface Water)	115	Colorimetry	0.11	mg/L	UKAS
Iron (Surfacewater)	177	ICPMS	653.2	ug/L	UKAS
Lead (Surface Water)	177	ICPMS	1.2	ug/L	UKAS
m-& p-Xylene	179	GCMS	<0.73	ug/L	
Magnesium	184	ICPMS	2.43	mg/L	
Manganese (Surface Water)	177	ICPMS	280	ug/L	UKAS
Mercury	178	ICPMS	<0.03	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	UKAS
Nitrogen (Total Oxidised) (Surface	151	Colorimetry	1.64	mg/L as N	UKAS
o-Xylene	179	GCMS	<0.35	ug/L	
pH (Surface Water)	110	Electrometry	7.5	pH Units	UKAS

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

Acc. : Accredited Parameters by ISO 17025:2005

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Water,Soil & Air Testing

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Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/080/02
		Date of Receipt	22/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Carlingford STP Downstream 22/10/09	*Sample Type*	Surface Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Phosphate (Ortho) Surface Water	117	Colorimetry	0.013	mg/L as P	UKAS
Potassium	184	ICPMS	1.75	mg/L	
Simazine	191	HPLC	<0.01	ug/L	
Sodium	184	ICPMS	8.89	mg/L	
Solids (Total Suspended)	106	Filtration/ Drying @ 104C	<2	mg/L	
Sulphate	119	Colorimetry	12.97	mg/L as SO4	
Toluene	179	GCMS	<0.28	ug/L	
Total Cyanide	0	Spectrometry	<0.05	mg/L	
Tributyltin*	0	GCMS	<0.02	ug/L as Sn	
Xylene (Total)	179	GCMS	<1	ug/L	
Zinc (Surface Water)	177	ICPMS	6.7	ug/L	UKAS

Web Certificate ***Date : 20/11/2009***

Donna Heslin - Laboratory Manager

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Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/080/05**
		Date of Receipt	**22/10/2009**
		Sampled On	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**29/01/2013**
Customer Ref	**Trial Hole 2 22/10/09**	***Sample Type***	**Soil**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
% Dry Matter	302	Drying @ 104 C	86.65	%	
Acenaphthene (Soil)	200	GCMS	<0.05	mg/Kg	
Acenaphthylene (Soil)	200	GCMS	<0.05	mg/Kg	
Anthracene (Soil)	200	GCMS	<0.02	mg/Kg	
Antimony (Leachate)	128	ICPMS	24.2	ug/Kg	
Arsenic (Leachate)	128	ICPMS	96.8	ug/Kg	
Barium (Leachate)	128	ICPMS	159.4	ug/Kg	
Benzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Benzo(a)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(a)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(b)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(ghi)perylene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(k)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Cadmium (Leachate)	128	ICPMS	<0.09	ug/Kg	
Chloride (Leachate WAC)	190	IC	24.11	mg/Kg	
Chromium (Leachate)	128	ICPMS	24.5	ug/Kg	
Chrysene (Soil)	200	GCMS	<0.05	mg/Kg	
Copper (Leachate)	128	ICPMS	114	ug/Kg	
Coronene (Soil)	200	GCMS	<0.05	mg/Kg	
Dibenzo(ah)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Dissolved Organic Carbon (Leachate)	316	TOC Analyser	165	mg/Kg	
Ethylbenzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluorene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluoride (Leachate WAC)	190	IC	5.74	mg/Kg	

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

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Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.fitzsci.ie
email: info@fitzsci.ie

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Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/080/05**
		Date of Receipt	**22/10/2009**
		Sampled On	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**29/01/2013**
Customer Ref	**Trial Hole 2 22/10/09**	***Sample Type***	**Soil**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Indeno(1,2,3-cd)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Lead (Leachate)	128	ICPMS	2	ug/Kg	
Mercury (Leachate)	128	ICPMS	<0.2	ug/Kg	
Mineral oil by Calculation (solid)	327	GC-FID	121.6	mg/Kg	
Molybdenum (Leachate)	128	ICPMS	168.8	ug/Kg	
Naphthalene (Soil)	200	GCMS	<0.05	mg/Kg	
Nickel (Leachate)	128	ICPMS	57.6	ug/Kg	
PAH soil (Sum of 17)	200	GCMS	<0.05	mg/Kg	
PCBs (Soil)	323	GCMS	<0.005	mg/Kg	
Phenanthrene (Soil)	200	GCMS	<0.05	mg/Kg	
Phenol Index (Leachate)	128	Colorimetry	0.07	mg/Kg	
Pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Selenium (Leachate)	128	ICPMS	19.8	ug/Kg	
Sulphate (Leachate WAC)	190	IC	187.59	mg/Kg	
TOC (Soil)	315	TOC Analyser	5.146	%	
Total Dissolved Solids (Leachate)	128	Evaporation/ Gravimetry	1580	mg/Kg	
Total Xylene (Soil)	198	GC-FID	<1	mg/Kg	
Zinc (Leachate)	128	ICPMS	<4.6	ug/Kg	

Signed : A Harmon ***Date : 29/01/2013***

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Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.fitzsci.ie
email: info@fitzsci.ie

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		Date of Receipt	**22/10/2009**
		Sampled On	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**29/01/2013**
Customer Ref	**Trial Hole 1 22/10/09**	***Sample Type***	**Soil**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
% Dry Matter	302	Drying @ 104 C	74.1	%	
Acenaphthene (Soil)	200	GCMS	<0.05	mg/Kg	
Acenaphthylene (Soil)	200	GCMS	<0.05	mg/Kg	
Anthracene (Soil)	200	GCMS	<0.02	mg/Kg	
Antimony (Leachate)	128	ICPMS	47.6	ug/Kg	
Arsenic (Leachate)	128	ICPMS	106.4	ug/Kg	
Barium (Leachate)	128	ICPMS	235.7	ug/Kg	
Benzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Benzo(a)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(a)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(b)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(ghi)perylene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(k)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Cadmium (Leachate)	128	ICPMS	0.3	ug/Kg	
Chloride (Leachate WAC)	190	IC	15.51	mg/Kg	
Chromium (Leachate)	128	ICPMS	20.5	ug/Kg	
Chrysene (Soil)	200	GCMS	<0.05	mg/Kg	
Copper (Leachate)	128	ICPMS	219.2	ug/Kg	
Coronene (Soil)	200	GCMS	<0.05	mg/Kg	
Dibenzo(ah)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Dissolved Organic Carbon (Leachate)	316	TOC Analyser	289	mg/Kg	
Ethylbenzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluorene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluoride (Leachate WAC)	190	IC	7.14	mg/Kg	

Signed : A Harmon ***Date : 29/01/2013***

Aoife Harmon - Technical Supervisor

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Unit 35,
Boyne Business Park,
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Tel: +353 41 9845440
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email: info@fitzsci.ie

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Customer	**Pamela Dagg** **Louth Co. Co.** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/080/03**
		Date of Receipt	**22/10/2009**
		Sampled On	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**29/01/2013**
Customer Ref	**Trial Hole 1 22/10/09**	***Sample Type***	**Soil**
Ref 2			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Indeno(1,2,3-cd)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Lead (Leachate)	128	ICPMS	8.3	ug/Kg	
Mercury (Leachate)	128	ICPMS	<0.2	ug/Kg	
Mineral oil by Calculation (solid)	327	GC-FID	89.9	mg/Kg	
Molybdenum (Leachate)	128	ICPMS	248.9	ug/Kg	
Naphthalene (Soil)	200	GCMS	<0.05	mg/Kg	
Nickel (Leachate)	128	ICPMS	36.4	ug/Kg	
PAH soil (Sum of 17)	200	GCMS	<0.05	mg/Kg	
PCBs (Soil)	323	GCMS	<0.005	mg/Kg	
Phenanthrene (Soil)	200	GCMS	<0.05	mg/Kg	
Phenol Index (Leachate)	128	Colorimetry	0.06	mg/Kg	
Pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Selenium (Leachate)	128	ICPMS	20.1	ug/Kg	
Sulphate (Leachate WAC)	190	IC	230.94	mg/Kg	
TOC (Soil)	315	TOC Analyser	7.692	%	
Total Dissolved Solids (Leachate)	128	Evaporation/ Gravimetry	1980	mg/Kg	
Total Xylene (Soil)	198	GC-FID	<1	mg/Kg	
Zinc (Leachate)	128	ICPMS	11.8	ug/Kg	

Signed : A Harmon ***Date : 29/01/2013***

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Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland

Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	Pamela Dagg Louth Co Co Enforcement Section Louth County Council Millenium Centre , Dundalk County Louth	*Lab Report Ref. No.*	2710/080/04
		Date of Receipt	22/10/2009
		Date Testing Commenced	23/10/2009
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO	4/113765	*Date of Report*	20/11/2009
Customer Ref	Trial Hole 4 22/10/09	*Sample Type*	Water

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
% Dry Matter	302	Drying @ 104 C	79.74	%	
Acenaphthene (Soil)	204	GCMS	<0.05	mg/Kg	
Acenaphthylene (Soil)	204	GCMS	<0.05	mg/Kg	
Anthracene (Soil)	200	GCMS	<0.02	mg/Kg	
Antimony (Leachate)	128	ICPMS	52.9	ug/Kg	
Arsenic (Leachate)	128	ICPMS	123.4	ug/Kg	
Barium (Leachate)	128	ICPMS	418.7	ug/Kg	
Benzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Benzo(a)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(a)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(b)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(ghi)perylene (Soil)	200	GCMS	<0.05	mg/Kg	
Benzo(k)fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Cadmium (Leachate)	128	ICPMS	0.2	ug/Kg	
Chloride (Leachate WAC)	190	IC	53.57	mg/Kg	
Chromium (Leachate)	128	ICPMS	12.7	ug/Kg	
Chrysene (Soil)	200	GCMS	<0.05	mg/Kg	
Copper (Leachate)	128	ICPMS	242.4	ug/Kg	
Coronene (Soil)	200	GCMS	<0.05	mg/Kg	
Dibenzo(ah)anthracene (Soil)	200	GCMS	<0.05	mg/Kg	
Dissolved Organic Carbon (Leachat	316	TOC Analyser	374	mg/Kg	
Ethylbenzene (Soil)	198	GC-FID	<0.5	mg/Kg	
Fluoranthene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluorene (Soil)	200	GCMS	<0.05	mg/Kg	
Fluoride (Leachate WAC)	190	IC	9.69	mg/Kg	

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Donna Heslin - Laboratory Manager

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Unit 35,
Boyne Business Park,
Drogheda,
Co. Louth
Ireland
Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer	**Pamela Dagg** **Louth Co Co** **Enforcement Section** **Louth County Council** **Millenium Centre , Dundalk** **County Louth**	***Lab Report Ref. No.***	**2710/080/04**
		Date of Receipt	**22/10/2009**
		Date Testing Commenced	**23/10/2009**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO	**4/113765**	***Date of Report***	**20/11/2009**
Customer Ref	**Trial Hole 4 22/10/09**	***Sample Type***	**Water**

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Indeno(1,2,3-cd)pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Lead (Leachate)	128	ICPMS	5.9	ug/Kg	
Mercury (Leachate)	128	ICPMS	<0.2	ug/Kg	
Mineral oil by Calculation (solid)	327	GC-FID	13.09	mg/Kg	
Molybdenum (Leachate)	128	ICPMS	404.5	ug/Kg	
Naphthalene (Soil)	200	GCMS	<0.05	mg/Kg	
Nickel (Leachate)	128	ICPMS	74.8	ug/Kg	
PAH soil (Sum of 17)	200	GCMS	<0.05	mg/Kg	
PCBs (Soil)	323	GCMS	<0.005	mg/Kg	
Phenanthrene (Soil)	200	GCMS	<0.05	mg/Kg	
Phenol Index (Leachate)	128	Colorimetry	0.1	mg/Kg	
Pyrene (Soil)	200	GCMS	<0.05	mg/Kg	
Selenium (Leachate)	128	ICPMS	23.4	ug/Kg	
Sulphate (Leachate WAC)	190	IC	609.13	mg/Kg	
TOC (Soil)	315	TOC Analyser	6.755	%	
Total Dissolved Solids (Leachate)	128	Evaporation/ Gravimetry	3420	mg/Kg	
Total Xylene (Solid)	198	GC-FID	<1	mg/Kg	
Zinc (Leachate)	128	ICPMS	<4.6	ug/Kg	

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Donna Heslin - Laboratory Manager

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APPENDIX 4

Landfill Gas Report

APPENDIX 5

Geophysical Report

AGL09301_01

REPORT

ON THE

GEOPHYSICAL SURVEY

AT A

LANDFILL

AT

CARLINGFORD, CO. LOUTH

FOR

SITE INVESTIGATIONS LTD.

8th January 2010

PRIVATE AND CONFIDENTIAL

THE FINDINGS OF THIS REPORT ARE THE RESULT OF A GEOPHYSICAL SURVEY USING NON-INVASIVE SURVEY TECHNIQUES CARRIED OUT AT THE GROUND SURFACE. INTERPRETATIONS CONTAINED IN THIS REPORT ARE DERIVED FROM A KNOWLEDGE OF THE GROUND CONDITIONS, THE GEOPHYSICAL RESPONSES OF GROUND MATERIALS AND THE EXPERIENCE OF THE AUTHOR. APEX GEOSERVICES LTD. HAS PREPARED THIS REPORT IN LINE WITH BEST CURRENT PRACTICE AND WITH ALL REASONABLE SKILL, CARE AND DILIGENCE IN CONSIDERATION OF THE LIMITS IMPOSED BY THE SURVEY TECHNIQUES USED AND THE RESOURCES DEVOTED TO IT BY AGREEMENT WITH THE CLIENT. THE INTERPRETATIVE BASIS OF THE CONCLUSIONS CONTAINED IN THIS REPORT SHOULD BE TAKEN INTO ACCOUNT IN ANY FUTURE USE OF THIS REPORT.

PROJECT NUMBER	AGL09235		
AUTHOR	**CHECKED**	**REPORT STATUS**	**DATE**
MALCOLM FITZELL B.A. MOD. (GEOLOGY)	EURGEOL PETER O'CONNOR P.GEO., M.SC. (GEOPHYSICS), DIP. EIA MGMT.	V.1	8TH JANUARY 2010

TABLE OF CONTENTS

1. SUMMARY

- APEX Geoservices Ltd. was requested by Site Investigations Ltd., on behalf of Louth County Council to carry out a geophysical survey on a landfill site at Carlingford, Co. Louth. The survey was carried out as part of an intrusive investigation to assess the extent and thickness of the waste material.
- The purpose of the survey was to identify the extent and thickness of the waste material, and to provide information on the nature of the waste mass and backfill.
- The geophysical survey comprised EM31 ground conductivity mapping, 2D resistivity profiling and seismic refraction profiling.
- The geophysical data indicated 0-4.3m soft to firm or loose to medium dense landfill waste material across most of the site, with an average thickness of 2.5-3.0m. The interpreted base of the landfill waste lies at 1-2.5mOD generally.
- The geophysical survey indicates that the landfill is 1.15 Ha in area.
- The landfill has been interpreted as having been deposited mostly on a pre-existing channel of saline estuarine deposits which are indicated by low resistivity values and, to the north of the site, by very high conductivity values.
- Some zones of possible leachate have been interpreted underlying the waste.
- Possible leachate zones extend to the west and north of the site.
- ` The in phase values suggest that there is relatively little metal dispersed throughout the body of the landfill. Three localised zones of elevated conductivity or in phase component suggest possible significant metal in the waste at these localities.
- The leachate concentration to the north of the site and also towards the western boundary should be investigated by the installation of monitoring wells.
- Two cable percussive boreholes and one trial pit on the landfill are proposed to investigate whether moderately low resistivity/elevated conductivity is due to saline material or leachate underlying the waste.
- The geophysical data should be reviewed on completion of any further direct investigation.

2. INTRODUCTION

APEX Geoservices Ltd. was requested by Site Investigations Ltd., on behalf of Louth County Council to carry out a geophysical survey on a landfill site at Carlingford, Co. Louth. . The survey was carried out as part of an intrusive investigation to assess the extent and thickness of the waste material underlying the site.

2.1 Survey Objectives

The objectives of the geophysical survey were:

- To identify the extent and thickness of the waste material,
- To provide information on the nature of the waste mass and backfill.

Figure 1 Location Map

2.2 Site Background

The site is located approximately 600m south-east of Carlingford, Co. Louth. Most of the site is situated in a low lying area (approximately 1.2-4.0mOD) with the ground rising to the east and south-east up to approximately 8mOD and in the west to a maximum of approximately 14.5m. The site is bordered by a stream to the west. The northern portion of the site is also bordered by a small stream. These streams join at the northern limit of the site from where they drain northward to the sea at Carlingford Lough.

The site is 1.44 Ha in area (the area inside the boundary shown in red in Drawing 9301-01, Fig. 1). This includes a sewerage treatment plant surrounded by a security fence enclosing an area of 0.7 Ha, located in the southern portion of the site. Much of the northern portion of the site outside the security fence is covered by gorse. This northern portion includes a mound approximately 4-6m high. Waste (domestic and C&D) was found to be exposed in places on the slopes of this mound.

The geophysical survey described in this report was continued outside the site boundary, extending to approximately 4.3 Ha, in order to cover possible additional waste material.

The geological map for the area (Geological Survey of Ireland) indicates that the survey area is underlain by the undifferentiated Dinantian limestones which are shown as outcropping approximately 65m to the south-west of the site.

The Geological Survey of Ireland archival 6 inch:1 mile geological field map for the area indicates a "marshy flat part below high water mark" which includes much of the area of the present site (Drawing 9301-02). A small part of the south-eastern portion of the site is shown as "undulating drift". The area of marshy ground is shown as extending for over 600m to the north of the site and to include a raised beach approximately 475m NNW of the site. This map also indicates a small limestone quarry in the north-east of the sewerage works compound.

The Teagasc Soil map indicates glacial till derived from Lower Palaeozoic sandstone and shale across most of the site with a narrow strip of ground underlain by marine sands and gravels along the western boundary and which broadens out to the north of the site. Till derived from granite is shown as occurring to the west of the marine deposits.

The Geological Survey of Ireland national draft bedrock aquifer map indicates the aquifer for the area as "Locally Important Aquifer-Bedrock which is Generally Moderately Productive".

The Geological Survey of Ireland national groundwater vulnerability map indicates a vulnerability rating for most of the site as "High to Low-Only an Interim Study Took Place", with a small area in the extreme south-west of the site as having "Extreme" vulnerability.

13 trial pits were opened prior to the geophysical survey. A groundwater monitoring borehole was also drilled. Logs were received for the trial pits but not for the borehole. 11 of the trial pits were excavated in or west of the sewage treatment compound on the 22-23 October 2009 and two trial pits were dug in the gorse area north of the compound. The locations of the trial pits are indicated on Drawing 9301-01; Figure 1. The trial pits were dug to depths of approximately 1m beneath the waste. Made ground with waste material was found in all of the pits and comprised stone, concrete, plastic, glass bottle, cable, re-bar, tyre, car part, brick, timber, tree branches, wavin pipe, electrical item (radio), metal, bicycle, foam, wire, chain, straw, bones, hay bale, canvas sacks, newspapers, wheel rim, and battery casing. The thickness of the made ground/waste exposed in the trial pits varied from 0.4m to 3.95m with the base of the waste between 0.7m and 4.25m below ground level and with topsoil/capping thickness of 0.3-1.8m. Oily/hydrocarbon odour was noted from waste in two trial pits. No leachate was recorded in the trial pits.

2.3 Survey Methodology

The following methods were used in carrying out the geophysical survey:

- EM31 ground conductivity mapping to provide information on the lateral extent and variations in the composition of the material in the top 6m of the subsurface including waste material.

- 2D resistivity profiles across accessible parts of the site to provide information on the thickness of the waste and identify depth to and extent of possible leachate.

- Seismic refraction profiling to provide information on the stratigraphy of the overburden material and waste material and to map the bedrock surface.

3. INTERPRETED RESULTS

The integrated geophysical results from each of the methods used are summarized on Drawing 9301-01, Figure 4 and on the interpreted sections included on Drawing 9301-03, Figures 3-5.

3.1 EM31 Conductivity

The EM31 conductivity survey locations are shown on Drawing 9301-03, Figure 1. The conductivity survey included additional readings taken outside the site boundary, as requested by Louth County Council engineer. These additional readings were taken to the north, west and east of the site.

The recorded EM31 conductivity values are contoured on Drawing 9301-01, Figure 2. The conductivity values ranged from 3 to 254 milliSiemens/metre (mS/m). The EM31 conductivity values have been broadly interpreted on the following basis:

Conductivity (mS/m)	**Interpretation of 0-6m Below Ground Level**
30-255	Saline Estuarine Deposits
30-60	Landfill Waste
20-30	Possible leachate
3-20	Clayey Sand/Gravel/Shallow Bedrock

During the survey an in phase component value was acquired simultaneously with the EM31 conductivity data. Variations in this component are indicative of the presence of metallic objects. The EM31 inphase values are contoured on Drawing 9301-03, Figure 3.

The EM31 in phase values ranged from 744-1482 with a background value of 744-1405 units. The in phase values have been broadly interpreted on the following basis:

In–Phase	**Interpretation of 0-6m Below Ground Level**
<900	Background values
>900	Indicative of Made Ground/Waste containing Dispersed Metal

3.2 2D Resistivity Profiling

Five resistivity profiles were recorded across the site at accessible locations. The locations are indicated on Drawing 9301-01, Figure 1. The interpreted sections are included on Drawing 9301-03, Figures 3-5. The resistivity data have been interpreted on the following basis:

Apparent Resistivity (ohm-m)	**Interpretation**
90-450	Topsoil/Capping
45-450	Landfill Waste
33-90	Possible Leachate
,5-33	Saline Estuarine Deposits with Possible Leachate
33-115	Clay/Gravelly Clay
115-650	Clayey Sand/Gravel
65-650+	Limestone/Argillaceous Limestone Bedrock

3.3 Seismic Refraction Profiling

One seismic refraction profile was recorded in close proximity to 2D Resistivity Profile R2. The location of this seismic profile is indicated on Drawing 9301-03, Figure 1.

The seismic data indicated 3 subsurface velocity layers which have been interpreted on the following basis:

P-wave Velocity Vp (m/s)	Interpretation
130-414	Topsoil, Capping & Soft/Loose Landfill Material
473-908	Firm/Medium Dense Soil
2348-3190	Slightly Weathered to Fresh Rock

3.4 Integrated Interpretation

The geophysical interpretation is summarized on Drawing 9301-01, Figure 4.

The combined 2D resistivity and seismic data in conjunction with the trial pit data have been interpreted (Drawing 9301-03, Figures 3-5) as indicating the following subsurface layers:

Layer	Resistivity (ohm-m)	Velocity (m/s)	Interpretation	Estimated Stiffness
1	90-450	130-414	Topsoil/Capping	Soft/Loose
	45-450		Landfill Waste	
2	33-90	473-908	Possible Leachate	Firm/Medium Dense
	<5-33		Saline Estuarine Deposits with Possible Leachate	
	33-115		Clay/Gravelly Clay	
	115-650		Clayey Sand/Gravel	
3	65-650+	2348-3190	Limestone/Argillaceous Limestone Bedrock	

The combined data has been interpreted as indicating c.0.3-2.2m soft/loose topsoil and/or capping material overlying 0-4.3m soft to firm or loose to medium dense landfill waste material. The average thickness of the waste is approximately 2.5-3.0m The interpreted base of the landfill waste lies at 1-2.5mOD generally.

Material of low resistivity underlies much of the waste material (Resitivity Profiles R2-R5). The waste is relatively high resistivity material, probably mixed domestic and C&D which would not be expected to generate leachate of such low resistivity (<5-33 Ohm.m). Flat marshy ground has been mapped across this area and extending northwards to the coast and would be expected to be underlain by estuarine deposits. In our experience such deposits are likely to be saline and to be in this low resistivity range. A channel filled with saline estuarine deposits has been interpreted accordingly.

Moderately low resistivity material (33-90 Ohm.m) underlying the waste has been interpreted as possible leachate.

Higher resistivity material underlying the waste, as well as to the north-east, has been interpreted generally as clayey sand/gravel.

The in phase values suggest that there is relatively little metal dispersed throughout the body of the landfill.

The bedrock, which has been interpreted as limestone/argillaceous limestone, is nowhere in direct contact with the landfill waste. However zones of possible leachate have been interpreted as extending down to bedrock in places on all the Resistivity Profiles . Shallow rock has been interpreted to the west of the site (SW ends of Resistivity Profiles R1, R2 and R4) - this rock has been classed as having "Extreme" vulnerability and the extent and concentration of leachate in this direction should be established by the installation of monitoring wells.

3.5 Recommendations

The following site investigation programme comprising monitoring well boreholes, cable percussive boreholes and trial pits is proposed:

Borehole/Trial Pit No.	Type	Location (National Grid)	Depth (mbgl)	Objective	Priority
MW1	Monitoring well	319238,311150	12	Investigate slightly elevated conductivity zone (possible leachate) immediately north of site	1
MW2		319247,311035	14	Investigate slightly elevated conductivity zone (possible leachate) immediately west of site	2
MW3		319243,311084	17		3
CP1	Cable percussive borehole	319259,311091	18.5	Investigate whether moderately low resistivity/elevated conductivity is due to saline material or leachate	4
CP2		319288,311045	14.5		5
TP1	Trial pit	319256,311054	5	Investigate if elevated conductivity is due to possible metal in waste	6
TP2		319290,311045	5		7
TP3		319258,311028	5	Investigate whether moderately low resistivity/elevated conductivity is due to saline material or leachate	8
TP4		319347,311021	5	Investigate if elevated conductivity is due to possible metal in waste	9

Monitoring Well MW1 is proposed to investigate possible leachate extending north of the site. Monitoring Wells MW2 and MW3 are proposed to check for presence of leachate to the west of the site, where there is housing and the rock is shallow with extreme vulnerability rating. Boreholes CP1 and CP2 and Trial Pit TP3 are recommended to verify the interpretation of saline estuarine deposits under the waste and to check for leachate. Trial Pits TP1, TP2 and TP4 are proposed to check for metal content in the waste, as indicated by higher conductivity and/or in phase levels at these locations.

The geophysical data should be reviewed on completion of any further direct investigation.

4. REFERENCES

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'The blind zone problem in engineering geophysics', Geophysics, 24, pp 359-36.

APPENDIX I. GEOPHYSICAL METHODOLOGY

M1. EM31 Conductivity Mapping

This method operates on the principle of inducing currents in conductive substrata and measuring the resultant secondary electro-magnetic field. The strength of this secondary EM field is calibrated to give apparent ground conductivity in milliSiemens/metre (mS/m). As the effective penetration of this method is around 6m below ground level the measured conductivity is a function of the different overburden layers and/or rock from 0 to 6m below ground level.

The equipment used was a GF EM31 Conductivity meter equipped with data logger. This instrument features a real time graphic display of the previous 20 measurement points to monitor data quality and results. 1470 conductivity readings were recorded on the 21st December 2009.

Conductivity and in-phase values were recorded on an approximate 2.5m x 7.5m grid which varies due to accessibility and the requirement for standoff from fences. Local conditions and variations were recorded.

The data were downloaded and plotted. Assignation of material types and possible anomaly sources was carried out, with cross-reference to other data. A scaled plot of conductivity against distance was prepared (Drawing 9301-01, Figure 2). The contoured in phase results are also shown (Drawing 9301-01, Figure 3).

M2. 2D Resistivity Profiling

2D Resistivity profiling makes use of the Wenner resistivity array. The 2D-resistivity profiling method records a large number of resistivity readings in order to map lateral and vertical changes in material types. The 2D-resistivity profiling method in this survey involves the use of up to 32 electrodes connected to a resistivity meter, using computer software to control the process of data collection and storage

Five profiles were recorded on the 21st December 2009. The profiles were recorded using a Tigre resistivity meter, imaging software, one 32 takeout multicore cable and up to 32 stainless steel electrodes. The recorded data was processed and viewed immediately after the survey.

Length and specifications of resistivity profiles:

Profile	Length (m)	No. of electrodes	Electrode spacing (m)	Depth of penetration (m)
R1	155	32	5	30
R2	155	32	5	30
R3	93	32	3	16
R4	155	32	5	30
R5	90	31	3	16

The field readings were stored in computer files and inverted using the RES2DINV package (Campus Geophysical Instruments, 1997) with up to 5 iterations of the measured data carried out for each profile to obtain a 2D-Depth model of the resistivities.

The inverted 2D-Resistivity models and corresponding interpreted geology are displayed as Profiles R1- R5 on Drawing 9301-03, Figures 3-5. The distance is indicated along the horizontal axis of the profile. All profiles have been contoured using the same contour intervals and colour codes.

M3. Seismic Profiling

Seismic profiling measures the velocity of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher seismic velocities while soft, loose or fractured materials have lower velocities. Readings are taken using geophones connected via multi-core cable to a seismograph.

A Geode high resolution 24 channel digital seismograph with geophone spacings of 3m was used. The source of the seismic waves was a sledgehammer. One seismic spread was recorded, in close proximity to Resistivity Profile R2.

Length and specifications of seismic profile:

Profile	Length	No. of geophones	Geophone spacing (m)
S1	69	24	3

First break picking in digital format was carried out using the FIRSTPIX software program to construct p-wave (Vp) traveltime plots for each spread. Velocity phases were selected from these plots using the GREMIX software program and were used to calculate the thickness of individual velocity units. Topographic data were input. Material types were assigned and estimation made of material properties, cross-referenced to the 2D Resistivity data. The processed seismic data are displayed on the relevant 2D resistivity profile on Drawing 9301_03, Figure 4.

Approximate errors for Vp velocities are estimated to be +/- 10%. Errors for the calculated layer thicknesses are of the order of +/-20%. Possible errors due to the "hidden layer" and "velocity inversion" effects may also occur (Soske, 1959).

APPENDIX II. SEISMIC REFRACTION PLATES

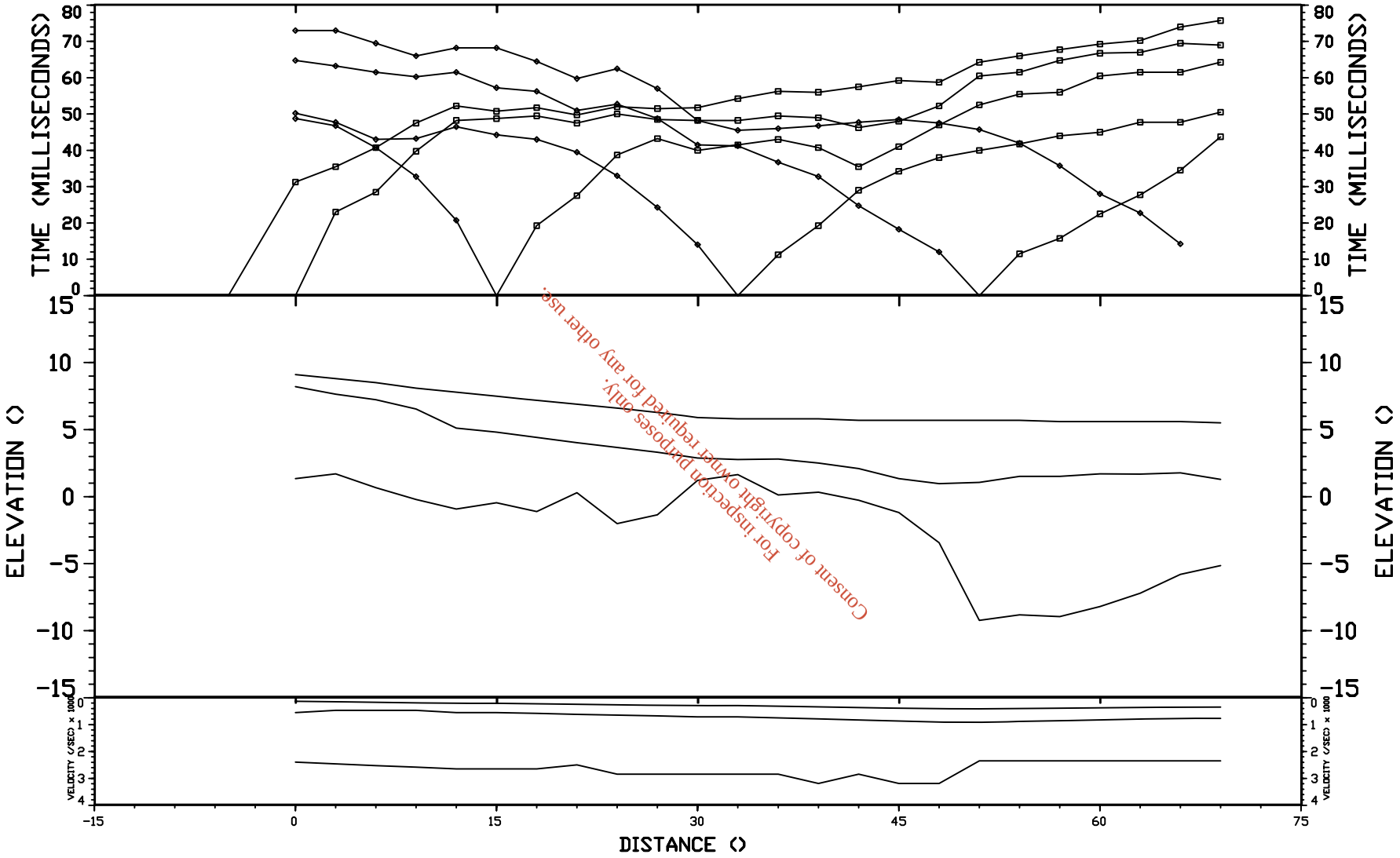


Plate: 10a

for: Louth Co. Council	9301
by: APEX Geoservices Ltd.	Carlingford Louth
Data SetS1 / Date:	
Equipment: / Spread: S1	Azimuth:

DRAWINGS

FIGURE 1: GEOPHYSICAL LOCATIONS & PREVIOUS TRIAL HOLE DATA

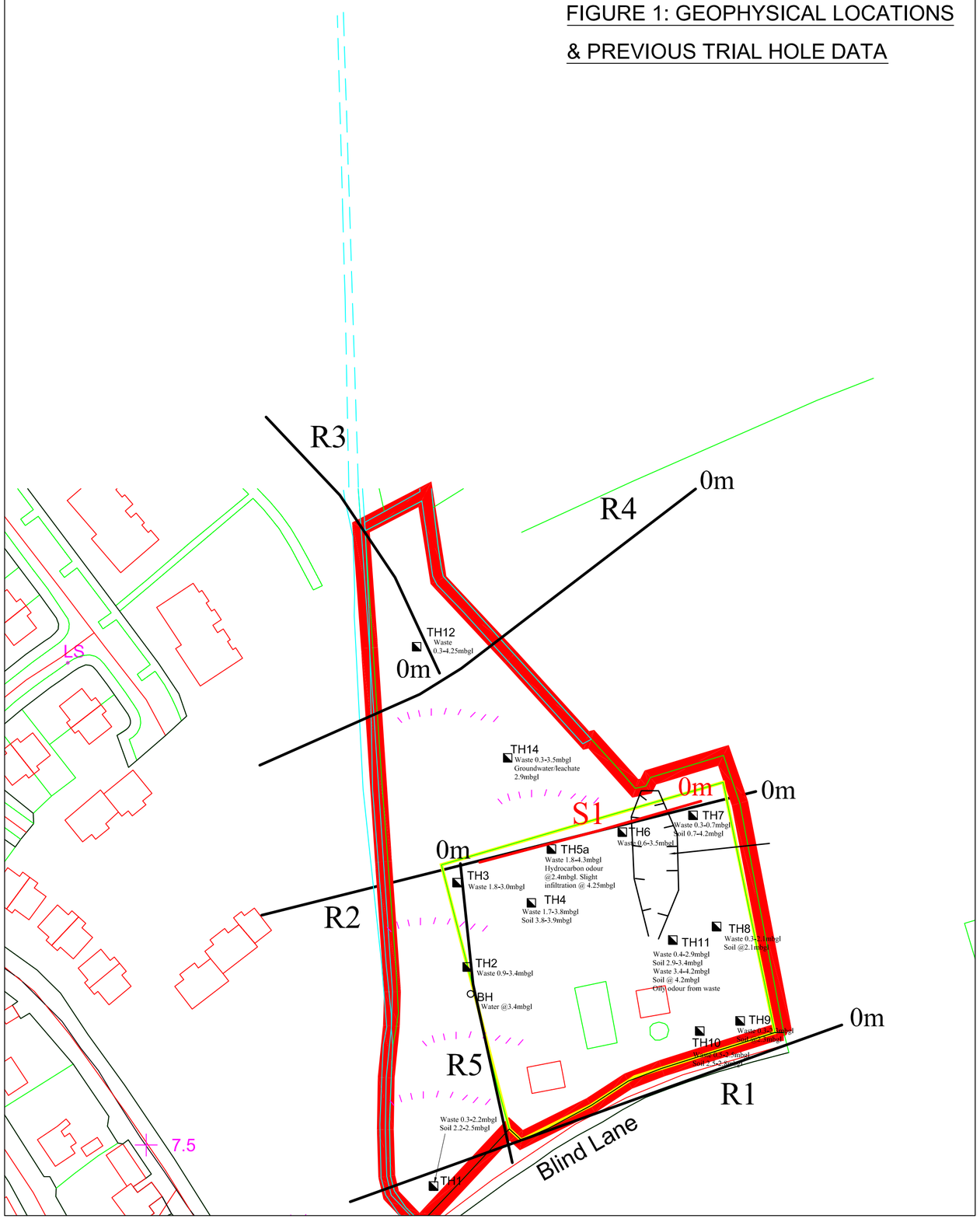


FIGURE 2: EM CONDUCTIVITY

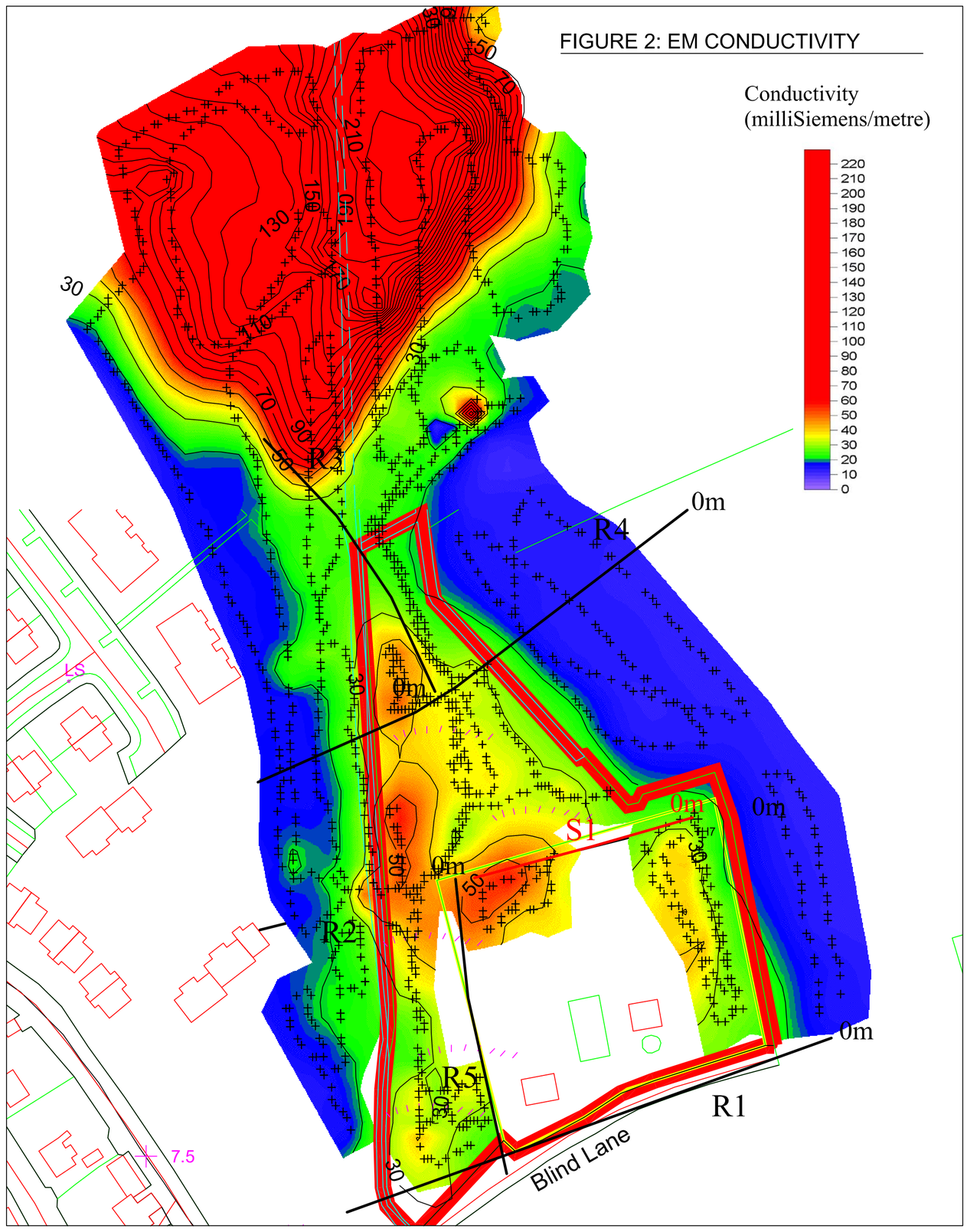


FIGURE 3: EM IN PHASE

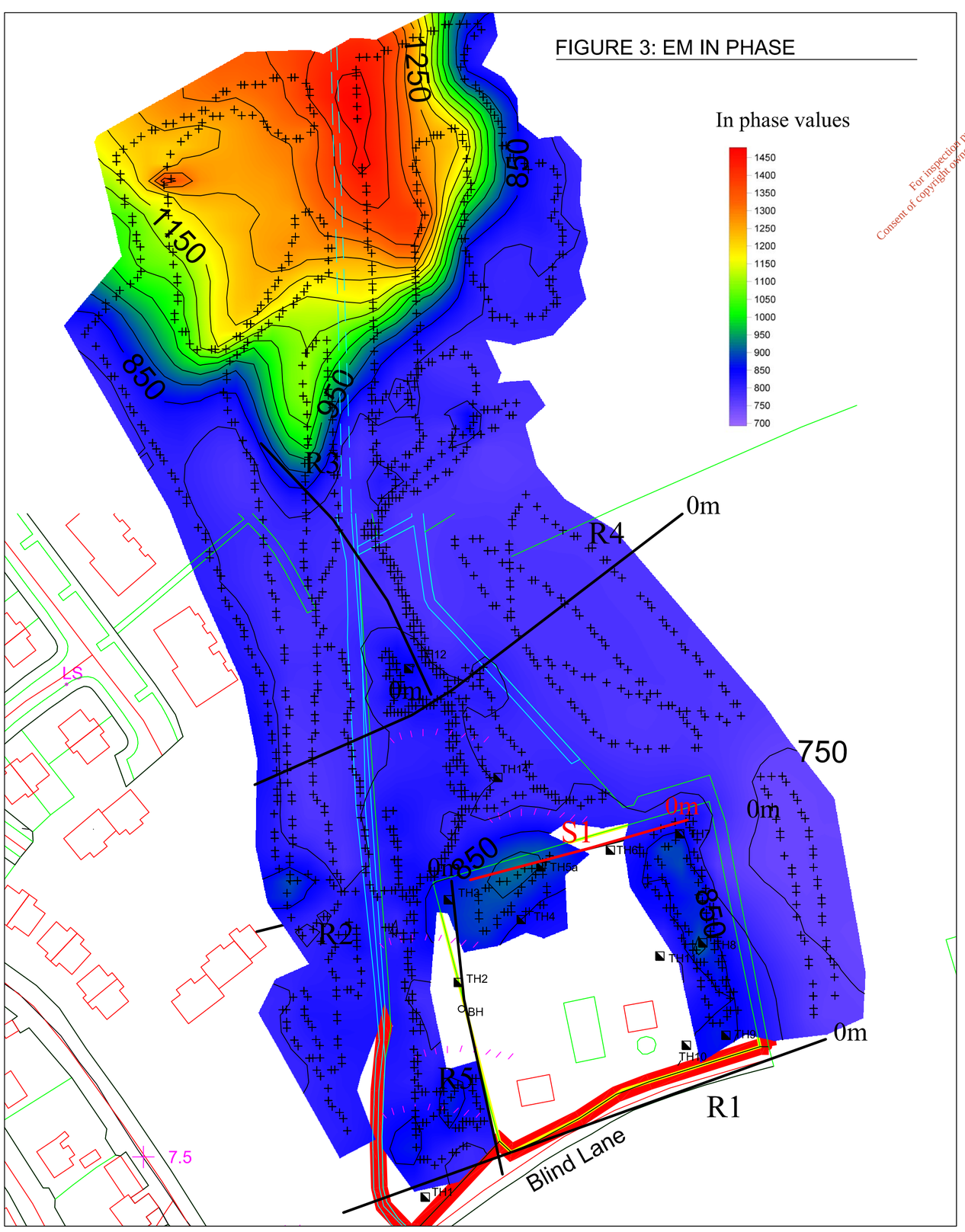
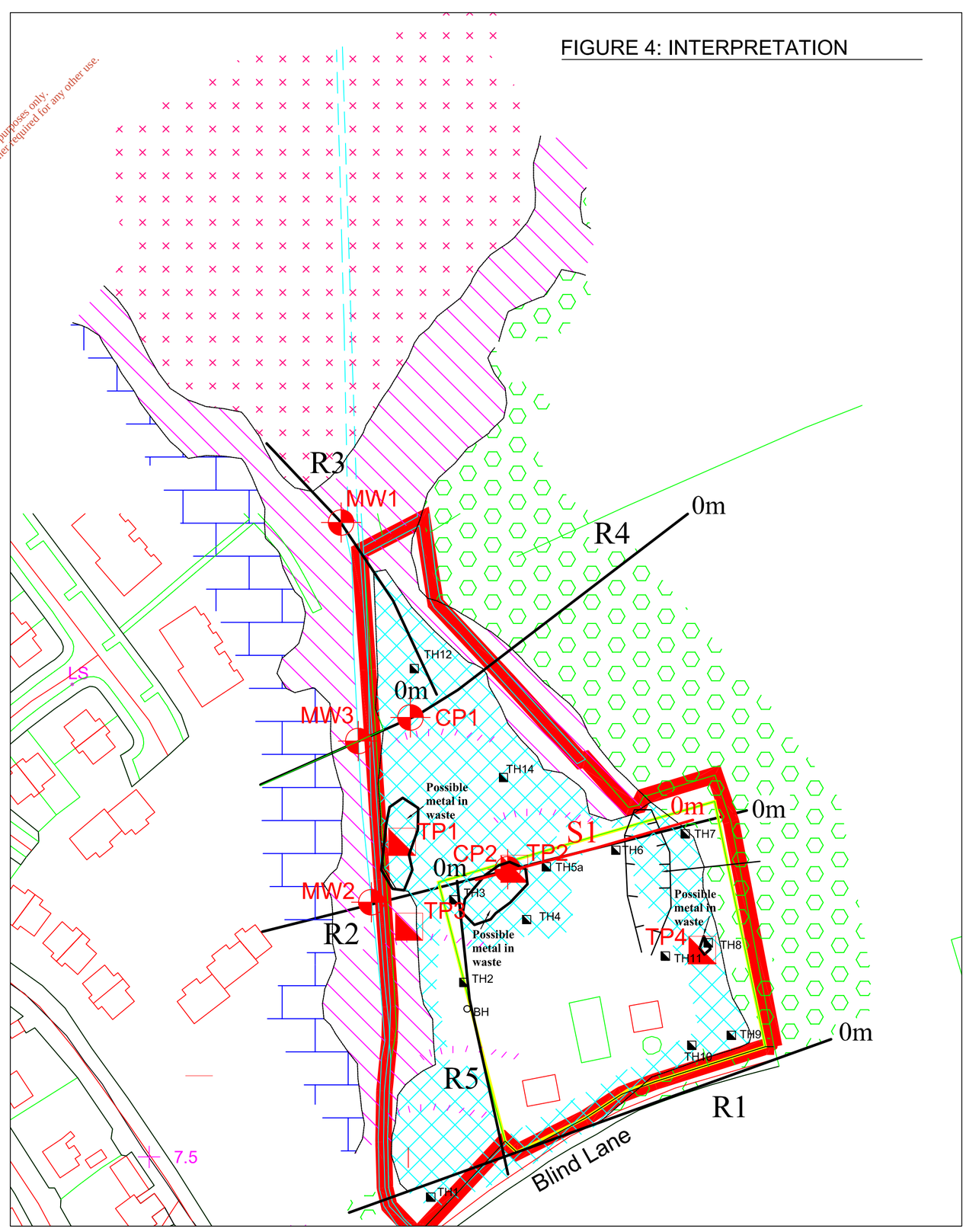
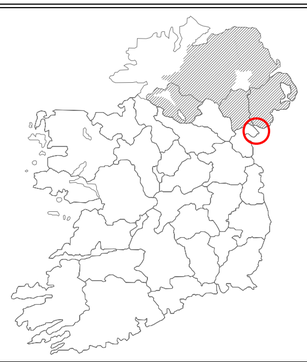


FIGURE 4: INTERPRETATION



INDEX MAP:



LEGEND:

- EM31 conductivity station
- 2D resistivity profile
- Seismic profile
- Watercourse
- Watercourse (approx/from archival map)
- Site boundary
- Boundary of sewerage treatment works compound
- Previous trial pit
- Proposed trial pit
- Proposed borehole
- MW — Monitoring well
- CP — Cable percussive borehole
- Landfill waste
- Possible leachate
- Saline estuarine deposits
- Clayey sand/gravel
- Shallow bedrock

TITLE:	GEOPHYSICAL SURVEY
PROJECT:	CARLINGFORD LANDFILL
CLIENT:	SITE INVESTIGATIONS LTD.
DRAWING:	GEOPHYSICS & INTERPRETATION
DRAWING NUMBER:	9301-01
SCALE:	1:1000
DATE:	6 JANUARY2010
DRAWN:	MF
CHECKED:	POC

REVISION:	DATE:	DRAWN:	CHECKED:

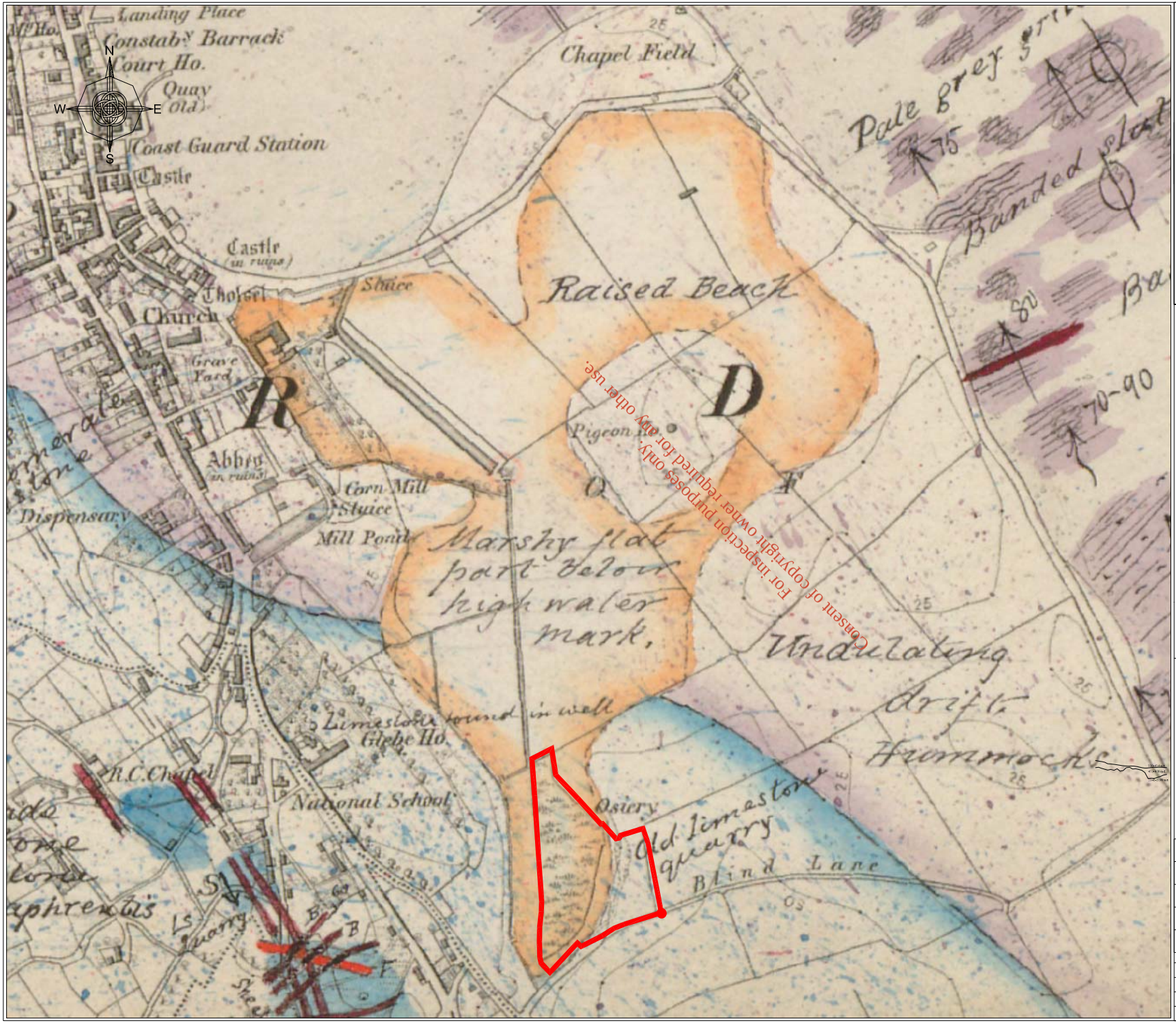
apex geoservices

Kilanerin,
Gorey,
Co. Wexford,
Ireland.

T +353 (0)402 21842
F +353 (0)402 21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

Unit 2, TLF Units,
Castle Lane Industrial Estate,
Melbourne,
Derby,
DE73 8DY

T +44 (0)844 8700 692
E info@apexgeoservices.co.uk
www.apexgeoservices.co.uk



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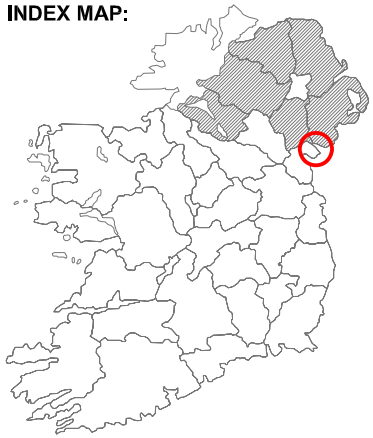


LEGEND:

Site boundary

apex geoservices

Kilanerin, Gorey, Co. Wexford, Ireland.
Tel. +353-(0)402-21842
Fax. +353-(0)402-21843
E: info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	CARLINGFORD GEOPHYSICAL SURVEY
DRAWING No.: 9301-02	GSI ARCHIVAL 6":1 MILE MAP
DATE:	6 JANUARY 2010
CLIENT:	SITE INVESTIGATIONS LTD.
SCALE:	1:5,000 @ A4

Version:	Date:	Drawn By:	Checked:
1	08.01.10	MF	POC

FIGURE 1: LOCATION MAP

FIGURE 2: GEOPHYSICAL LOCATIONS
Scale 1:2000

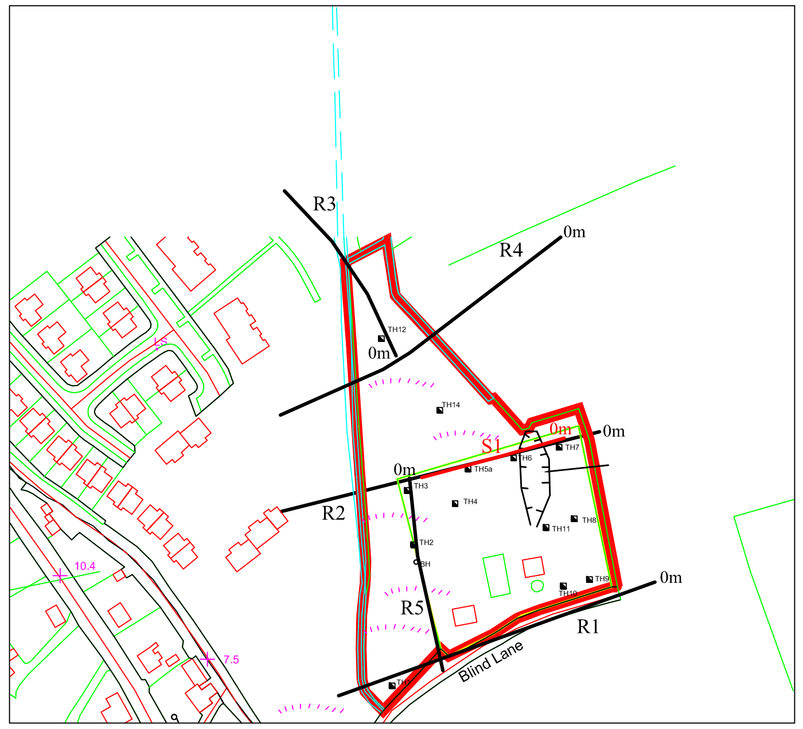


FIGURE 3: RESISTIVITY PROFILE R1
Scale 1:750

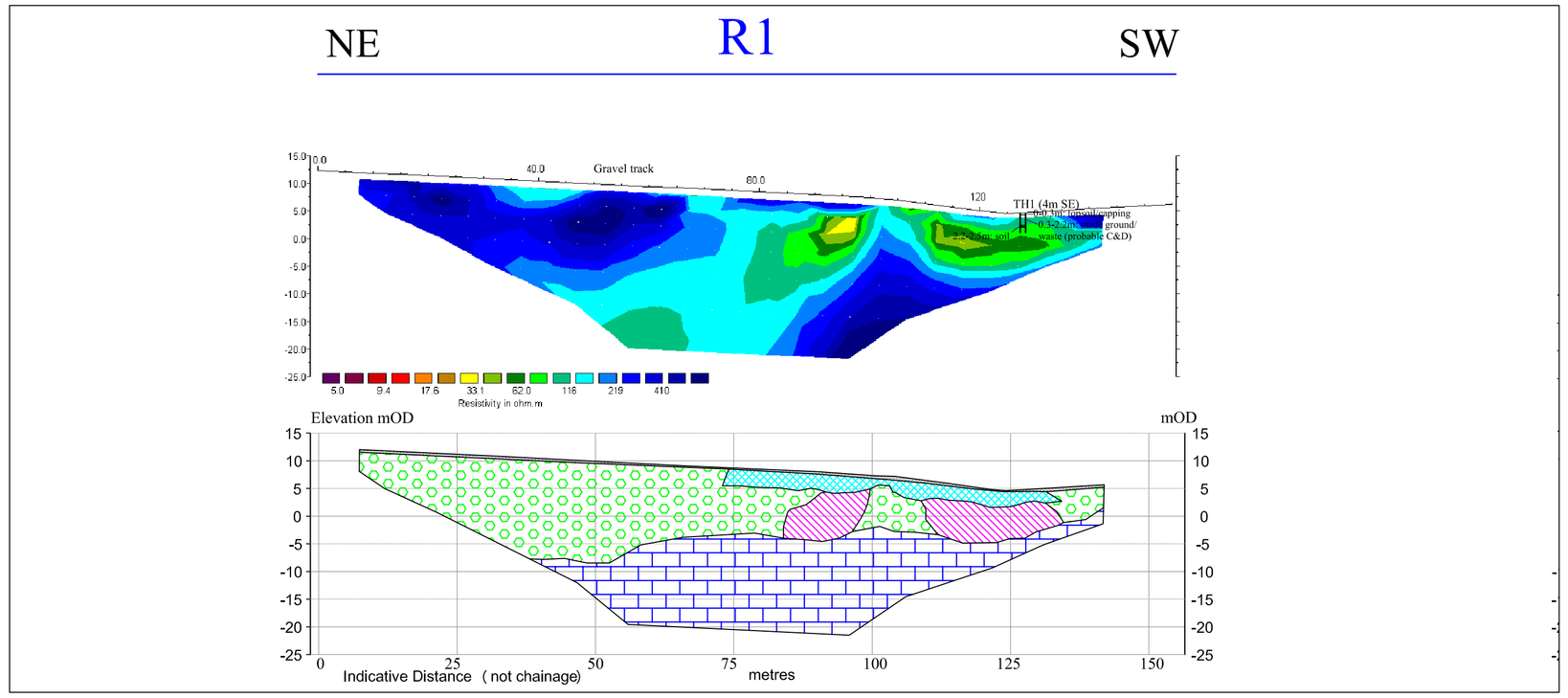


FIGURE 4: RESISTIVITY PROFILES R2-R3 & SEISMIC PROFILE S1
Scale 1:750

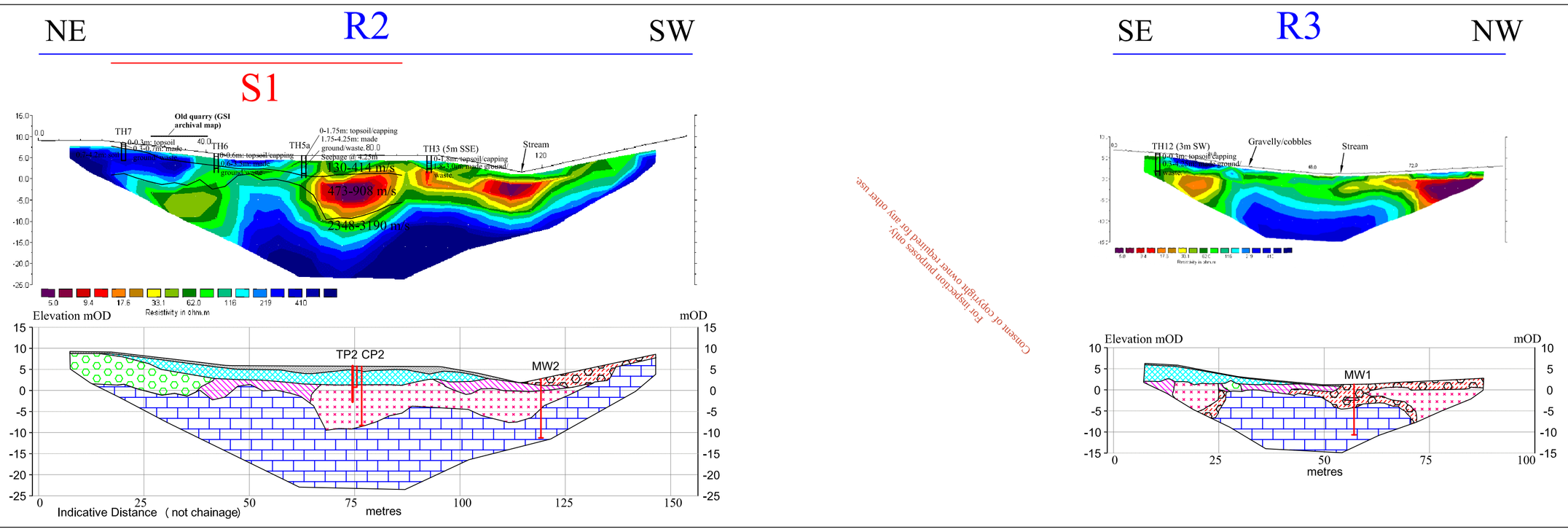
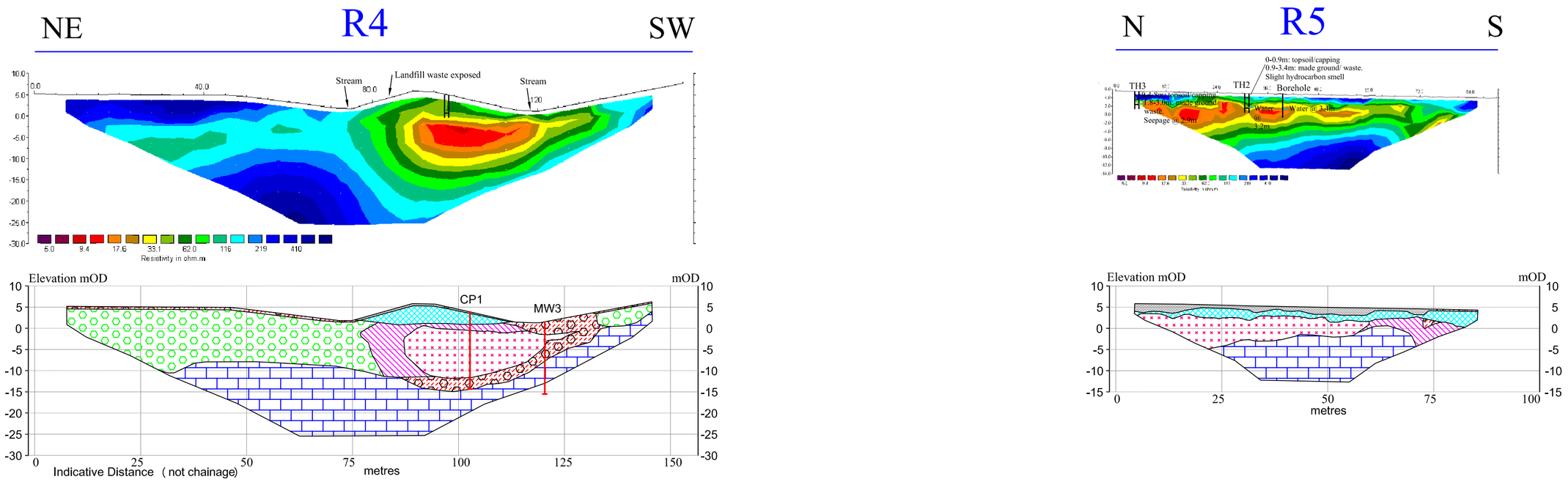


FIGURE 5: RESISTIVITY PROFILES R4 & R5
Scale 1:750



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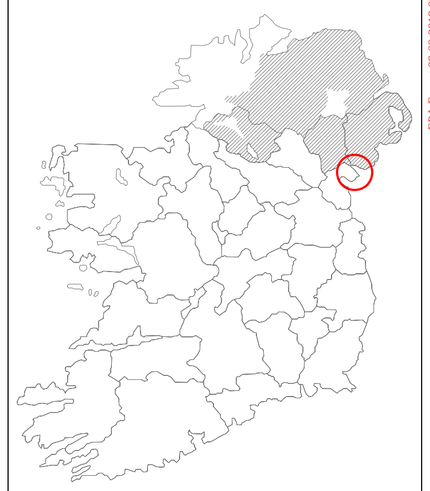

LEGEND:

- EM31 conductivity station
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- Possible leachate
- Saline estuarine deposits with possible leachate
- Clay / gravelly clay
- Clayey sand/gravel
- Limestone / argillaceous limestone bedrock
- Proposed borehole
- Proposed trial pit
- MW Monitoring well
- CP Cable percussive

NOTES:

TITLE:	GEOPHYSICAL SURVEY
PROJECT:	CARLINGFORD LANDFILL
CLIENT:	SITE INVESTIGATIONS LTD.
DRAWING:	RESISTIVITY & SEISMIC SECTIONS
DRAWING NUMBER:	9301_03
SCALE:	As indicated
DATE:	6th January 2010
DRAWN: MF	CHECKED: POC

REVISION:	DATE:	DRAWN:	CHECKED:

apex geoservices

Kilanerin,
Gorey,
Co. Wexford,
Ireland.

T +353 (0)402 21842
F +353 (0)402 21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

Unit 2, TLF Units,
Castle Lane Industrial Estate,
Melbourne,
Derby,
DE73 8DY

T +44 (0)844 8700 692
E info@apexgeoservices.co.uk
www.apexgeoservices.co.uk

APPENDIX 6

Stream Biological Assessment Report

BIOLOGICAL MONITORING OF WATER QUALITY IN THE VICINITY OF CARLINGFORD FORMER LANDFILL, COUNTY LOUTH

April 2010

Conservation Services, Tullaha, Glenflesk, Killarney, Co. Kerry
Tel/Fax 064 6630130 e-mail cs@conservation-services.ie

CONTENTS

1 INTRODUCTION

As part of the monitoring of water quality in the vicinity of the former landfill at Carlingford, Co. Louth, Conservation Services, Ecological & Environmental Consultants have been commissioned by Louth County Council to carry out biological sampling and water quality assessment in accordance with EPA Q-rating methodology at two locations on the stream adjacent to the former landfill.

Sampling was carried out on 7 April 2010.

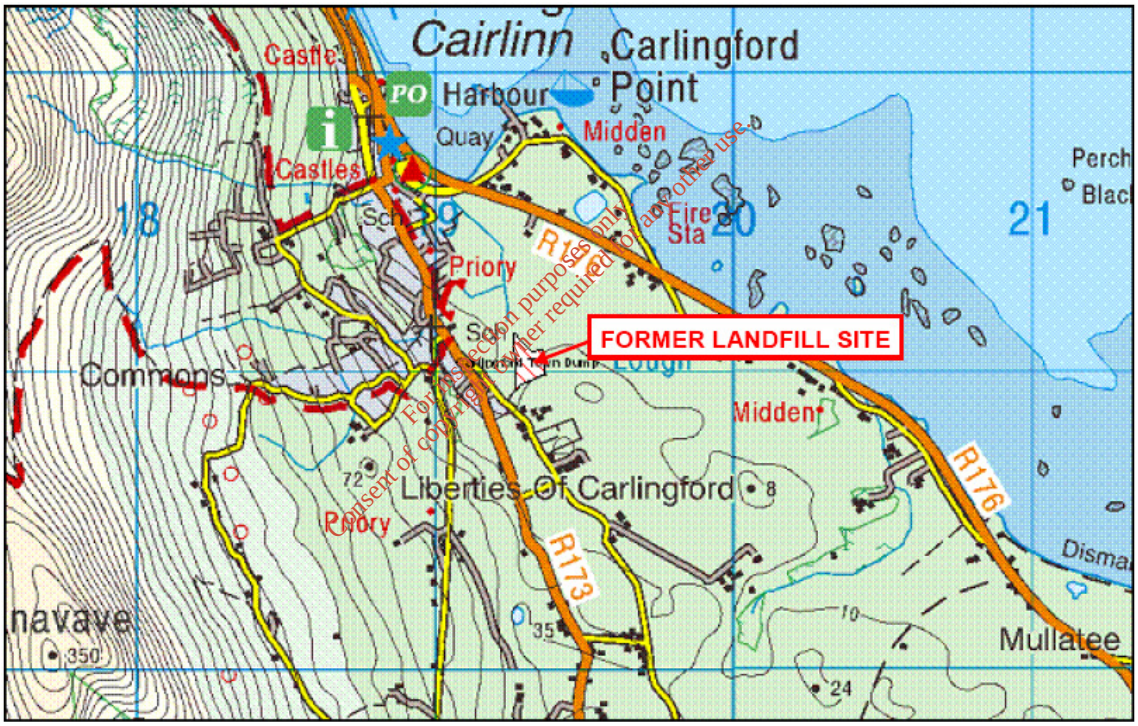

Fig. 1 Location map

2 METHODOLOGY

2.1 SITE LOCATIONS

Biological sampling and water quality assessment was carried out at the following sites specified by Louth County Council. The locations of the sites are shown on Figs. 1 & 2.

SITE	GRID REFERENCE (GPS)
1	J 1927 1099
2	J 1924 1116

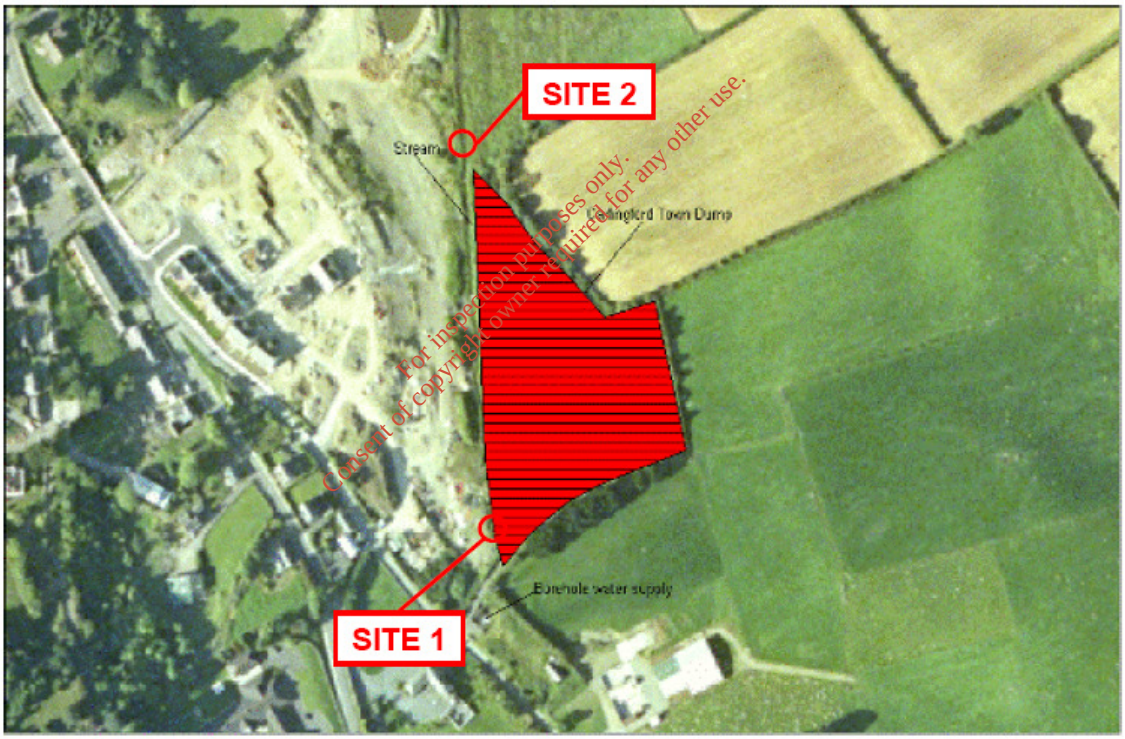

Fig. 2 Locations of sampling sites

Site 1 is located a short distance downstream of the upstream limit of the former landfill. A site immediately upstream of the landfill was not possible as the stream is culverted upstream of the former landfill. Site 2 is located immediately downstream of the former landfill Grid references were recorded at all sites using a GPS.

2.2 HABITAT ASSESSMENT

Habitat assessment was carried out at each of the sites selected for invertebrate/water quality assessment. These sites were assessed in terms of:

- Stream width and depth
- Substrate type, listing substrate fractions in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.
- Flow type, listing percentage of riffle, glide and pool in the sampling area
- Instream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site
- Dominant bankside vegetation, listing the main species overhanging the stream
- Estimated summer cover by bankside vegetation, giving percentage shade of the sampling site
- Rating of the site as habitat for trout adult, nursery and spawning on a scale of Poor/Fair/Good/Very Good/Excellent. This rating assesses the physical suitability of the habitat; the presence/absence/density of salmonids at the site will also depend on present and historical water quality and accessibility of the site to fish.

2.3 INVERTEBRATE SAMPLING AND WATER QUALITY ASSESSMENT

A sweep net invertebrate sample was taken at each site as the deep mud substrate rendered the site unsuitable for the standard kick sampling method employed by EPA. Each sample was retained in a large plastic bag at the sampling site. Sample processing and preservation was carried out under

laboratory conditions within 24 hours of sampling. Mud was removed from each sample by sieving under running water through a 500µ sieve. Sieved samples were then live sorted for 30 minutes in a white plastic sorting tray under a bench lamp (ISO 5667-3:1994) and if necessary using a magnifying lens. Macroinvertebrates were stored in 70% alcohol. Preserved invertebrates were identified to the level required for the EPA Q-rating method (Clabby *et al,* 2006) using high-power and low-power binocular microscopes when necessary. The preserved samples were archived for future examination or verification. Based on the relative abundance of indicator species, a biotic index (Q-rating) was determined for each site in accordance with the biological assessment procedure used by the Environmental Protection Agency (Clabby *et al* 2006) and more detailed unpublished methodology (McGarrigle, Clabby and Lucey pers. comm.).

Biotic Index	**Water Framework Directive Ecological Status**	**Quality Status**
Q5	High	Unpolluted Waters
Q4-5	High	
Q4	Good	
Q3-4	Moderate	Slightly Polluted Waters
Q3	Poor	Moderately Polluted Waters
Q2-3	Poor	
Q2	Bad	Seriously Polluted Waters
Q1-2	Bad	
Q1	Bad	

The scheme mainly reflects the effects of organic pollution (i.e. deoxygenation and eutrophication) but where a toxic effect is apparent or suspected the suffix '0' is added to the biotic index (e.g. Q1/0,2/0 or 3/0). An asterisk after a Q value

indicates something worthy of attention, typically heavy siltation of the substratum.

3 RESULTS

Habitat at sites is tabulated and site photographs are presented in Appendix 1.

3.1 SITE 1

The macroinvertebrate fauna recorded at the site merit a Q-rating of Q3 indicating poor ecological status and moderately polluted conditions.

INDICATOR GROUP	TAXON	Number
Group A - Very Pollution Sensitive	None Recorded	
Group B - Moderately Pollution Sensitive	Sericostomatidae	2
	Limnephilidae	3
Group C - Moderately Pollution Tolerant	*Gammarus duebeni*	47
	Chironomidae (ex. *Chironomus*)	53
Group D - Very Pollution Tolerant	*Glossiphonia complanata*	2
	Lymnaea peregra	c.450
Group E - Most Pollution Tolerant	Tubificidae	63
	Chironomus sp.	30
Not assigned to any indicator group	Lumbricidae	8
	Lumbriculidae	1

3.2 SITE 2

The macroinvertebrate fauna recorded at the site merit a tentative Q-rating of Q3/0 indicating poor ecological status and moderate levels of organic pollution with a suspected additional toxic effect on invertebrates.

INDICATOR GROUP	TAXON	Number
Group A - Very Pollution Sensitive	Nemouridae	1
Group B - Moderately Pollution Sensitive	Limnephilidae	4
Group C - Moderately Pollution Tolerant	Dytiscidae	1
	Chironomidae (ex. *Chironomus*)	159
Group D - Very Pollution Tolerant	*Glossiphonia complanata*	1
	Lymnaea peregra	1
Group E - Most Pollution Tolerant	Tubificidae	4
	Chironomus sp.	18
Not assigned to any indicator group	Lumbriculidae	10

4 DISCUSSION

On the basis of similar substrate conditions it would be expected that, in the absence of any impact between the upstream and downstream sites, the macroinvertebrate faunal communities would be broadly similar. The faunal communities at the two sites are in reality significantly different. Whereas gastropods (*Lymnaea peregra*) and crustaceans (*Gammarus duebeni)* are numerous at Site 1, they are virtually absent at Site 2 (a single *Lymnaea peregra* was recorded at the site). Furthermore, for a site with moderate levels of organic enrichment, the invertebrate abundance at Site 2 is abnormally low, for all groups except Chironomidae (excl. *Chironomus*) which frequently dominate the invertebrate community at sites which are suffering or are recovering from a significant perturbation.

Johnson, Wiederholm & Rosenberg (1993) state: "*Reduced total abundance and species richness and changes in macroinvertebrate dominance often occur in aquatic systems polluted by heavy metals. …Generally, insects appear to be less sensitive than gastropods and crustaceans to metal exposure*." Johnson, Wiederholm & Rosenberg (1993) also state: "*Crustacea as well as Mollusca (except for Sphaeriidae) are sensitive to low pH*."

The differences between the two sites are illustrated in the following table.

Percentage representation of faunal groups

	Site 1	**Site 2**
Gastropoda (Mollusca)	68%	0.5%
Crustacea	7%	0%
Insecta	9%	83%

5 CONCLUSIONS

The results of the present survey are suggestive of, but do not prove, an impact on the stream from the Carlingford former landfill. The biological data recorded downstream of the former landfill would be characteristic of a impact such as low level heavy metals pollution or a pollutant capable of reducing stream pH.

Signed on behalf of Conservation Services

_____

Bill Quirke BSc MSc MIEEM

_____

Helena Twomey BA(Mod.) PhD

Date

_____

6 REFERENCES

Johnson, R.K, T. Wiederholm & D.M. Rosenberg (1993) Freshwater Biomonitoring using individual organisms, populations, and species assemblages of Benthic Macroinvertebrates. In Rosenberg, D.M & V.H. Resh (eds). Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall.

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APPENDIX 1

HABITAT ASSESSMENT AT SAMPLING SITES

SITE 1

Site Code (Grid Reference)	J 1927 1099
Site Location	Just d/s culvert
Channel Width (m)	6-8
Depth (cm)	5-15
Substrate (in order of dominance)	Mud, Gravel (small amount)
Flow Type	Riffle 10% Glide 90%
Instream Vegetation	*Glyceria* sp. 20% *Rorippa nasturtium-aquaticum* agg. <5%
Dominant Bankside Vegetation	Grass, Nettle
Summer Shade of Stream by Bankside Vegetation	<5%
Trout Adult Habitat	None
Trout Nursery Habitat	Poor-None
Trout Spawning Habitat	None

Site 1

SITE 2

Site Code (Grid Reference)	J 1924 1116
Site Location	d/s tributary on RHS
Channel Width (m)	c. 8
Depth (cm)	5 - 15
Substrate (in order of dominance)	Mud
Flow Type	Glide 100%
Instream Vegetation	*Apium nodiflorum* 15% *Sparganium erectum* <5% *Rorippa nasturtium-aquaticum* agg. <5%
Dominant Bankside Vegetation	Grass
Summer Shade of Stream by Bankside Vegetation	<5%
Trout Adult Habitat	None
Trout Nursery Habitat	None
Trout Spawning Habitat	None
Lamprey Nursery	Good
Lamprey Spawning	None

Site 2