Eve O'Sullivan

Subject: H0394-01 COA Application FI - Castlerea Historic Landfill.
Attachments: H0394-01 FI Reply.pdf; Entec Risk Assessment for Castlrea Landfill Site.pdf; H0394-01 LFG Addendum.pdf

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From: Niall Kennedy <NKennedy@roscommoncoco.ie>
Sent: Monday 11 May 2020 16:43
To: Licensing Staff <licensing@epa.ie>
Subject: H0394-01 COA Application FI - Castlerea Historic Landfill.

A Chara,

Please find attached further information as per your request in accordance with Regulation 7(4) of the Waste Management (Certification of Historic Unlicenced Waste Disposal and Recovery Activity) Regulations, 2008.
If you have any further queries please let me know.

Yours Sincerely

Niall Kennedy
Executive Engineer
Environment
Roscommon County Council, Áras an Chontae, Roscommon, F42 VR98
Tel: 090 6637100 Email: nkennedy@roscommoncoco.ie Web: www.roscommoncoco.ie

Comhairle Contae
Ros Comáin
Roscommon
County Council

environment@roscommoncoco.ie

Ewa Babiarczyk.
Inspector,
Environmental Licensing Programme,
Office of Environmental Sustainability EPA,
PO Box 3000,
Johnstown Castle Estate,
County Wexford.

07th May 2020

Re: Further Information Application for Certificate of Authorisation
Castlerea Historic Landfill, Co. Roscommon – Site Code S22-02423

Dear Ms Babiarczyk,

I refer to the above application and your request in accordance with Regulation 7(4) of the Waste Management (Certification of Historic Unlicenced Waste Disposal and Recovery Activity) Regulations, 2008.

The following outlines the response to the items requested:

Item 1

a. Copy of Entec Report attached.
b. The initial report was prepared by Entec Limited. Entec (subsequently Amec Foster Wheeler and now a part of Wood Plc) are a highly professional, qualified and experienced environmental consultancy. In order to complete the risk assessment, Entec undertook site inspections, desk study, site investigation supervision and interpretation of investigation results. The report was prepared by professionally qualified and experienced personnel (PhD Contaminant Hydrogeology) and reviewed by an Associate Director (BSc Geology). Much of the information contained in this report was used by myself in undertaking the Tier 1 assessment. I have a BE in Civil Engineering and have undertaken relevant training in topics such as Waste Management, Landfill Risk Assessment, Landfill Gas Management, etc. This Tier 1 assessment was also reviewed by O'Callaghan Moran & Associates who are suitably qualified in accordance with section 2.3 of the EPA Code of Practice.

Item 2.

a. The volume of 83,000m^3 is confirmed as the volume of waste contained within the landfill.
b. The variation from the original volume, contained in the Entec report issued in 1999, is as a result of the more extensive site investigations undertaken by OCM in 2017 and also by the additional volume of waste deposited between the time the site investigations were undertaken in August 1998 and the date of final closure of the landfill.
c. As above

Item 3.

As detailed records are not available for the type of waste deposited at the landfill over its entire lifetime, it has to be assumed that the breakdown of waste types (80% domestic, 19% commercial, 1% road sweepings) contained in the risk assessment would be consistent throughout the entire site. This determination would have been as a result of local knowledge received from personnel and supervisors who had managed the facility throughout the years and also from site investigation works undertaken in preparation of the risk assessment report.

Item 4.

Landfill gas monitoring was undertaken in March 2020 and a report and interpretation is attached.

Item 5.

The reference in the report to the area referred to as "north of the Harristown Stream" is a typographical error and should read "south of the Harristown Stream".

The above responses do not impinge on the previously submitted non-technical summary or any drawings previously provided and so they have not been amended.

Yours sincerely

Niall Kennedy
Executive Engineer

ROSCOMMON COUNTY COUNCIL

PHYSICAL SETTING AND RISK ASSESSMENT FOR CASTLEREA LANDFILL SITE

FOR CLIENT COMMENT

PHYSICAL SETTING AND RISK ASSESSMENT FOR CASTLEREA LANDFILL SITE FOR CLIENT COMMENT

Technical Report
February 1999
By
ENTEC

Roscommon County Council
Courthouse
Roscommon
Co Roscommon

Report Issued By:
S SUTTON
5 February 1999

Reviewed By:
F CROZIER
5 February 1999

Entec

REPORT RELEASE SHEET

PHYSICAL SETTING AND RISK ASSESSMENT FOR CASTLEREA LANDFILL SITE

Roscommon County Council
Courthouse
Roscommon
Co Roscommon

Main Contributors

C N Rivers
B A Fretwell

Report Issued by:
S SUTTON

Report Reviewed by:
F CROZIER

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Carrick House, Dundrum, Dublin 14, Ireland
Tel (353) (0) 1 2984499 Fax: (353) (0) 1 2984957

Entec

SUMMARY

Castlerea Landfill occupies an area of some 4 ha, approximately 3 km south of Castlerea, Co Roscommon. Waste disposal to the landfill site ceased in late 1998. Site investigation of the thickness of the waste and nature of underlying soils and geology was carried out in August 1998. Sampling and chemical analysis of groundwater, surface water and leachate took place in September and December 1998.

This report presents the results of these investigations and summarises information on the history of waste disposal in the area based on the records of Roscommon County Council.

Interpretation of these results provide the basis for assessment of the environmental risks created by the closed landfill. The principal risk arises from the potential impact of leachate drainage to a nearby small stream. This risk can be minimised by reducing infiltration through low permeability capping and providing limited retention for leachate in the site perimeter drainage trenches. Oxidation and contaminant reduction can be further enhanced by promotion of reed and willow growth around the margins of the site and the provision of one or two small weirs in the ditches.

Gas venting through holes installed in the waste is also recommended.

CONTENTS

TABLES

FIGURES ***After Page***

APPENDICES

1. INTRODUCTION

1.1 Background

Castlerea Landfill site is a part land raise and landfill site about 4 ha in area located approximately 3 km to the south of the town of Castlerea in County Roscommon at National Grid Reference 168360 277500 (see Figure 1.1). The site is owned and was operated by Roscommon County Council and received the bulk of its waste as municipal waste from Castlerea and the surrounding areas.

The site was operated in two phases. In the first phase, in the eastern half, waste disposal started in the early-1960's and continued until 1988 after which it was closed and covered. The western area (second phase) of the site is reported to have become operational around 1988 and continued in use until the end of 1998. Some parts of the western area are currently undergoing restoration. Information received from Roscommon County Council suggests that throughout the lifetime of the site around 80% of the waste received was domestic waste with the remainder principally of commercial/light industrial origin and water treatment sludge. Appendix A provides a view of site use (by delivery vehicle type) from 1996-98.

The western area was nominally divided into the 2 areas during its lifetime. Filling occurred in a loosely planned manner. Waste was placed directly on the pre-existing ground surface. Little or no attempt has been made to regulate either leachate generation or collection.

1.2 Terms of Reference

In mid-1998, Roscommon County Council decided not to continue with the operation of Castlerea Landfill site. Under the Waste Management (Licensing) Regulations (1997) closure of the site by the end of 1998 became a legal requirement and Entec were commissioned to undertake an assessment of the site to define the level of environmental risk presented and to provide recommendations for any practicable remediation measures that might be appropriate.

The first stage of this risk assessment was to conduct a desk study and site investigation to obtain further information with regard to waste types and quantities, site layout and drainage, operational practices, surrounding landuse, geology, hydrology and hydrogeology. This site investigation was undertaken between

25 August 1998 and 29 August 1998. Further details of the investigation are given in Section 2.

1.3 Approach to Risk Assessment

This risk assessment has been undertaken using standard procedures used in the UK and Europe with reference to the guidelines and manuals produced by the EPA.

The standard approach to risk assessment of landfill sites as endorsed by the Department of the Environment (Waste Management Paper 26B, Appendix E) through the Environment Agency is to ascertain the HAZARDs from a site, and the TARGETs which could be at risk from the possible PATHWAYs. The risk is only significant where these three aspects are linked.

The principle risks associated with a closed municipal waste land raise facility such as that at Castlerea are:

- risks to surface and groundwater from continued leachate generation;
- risks related to continued landfill gas generation;
- risk related to intrusion of the waste by human and animal activity;
- aesthetic risks due to incomplete capping (litter is unsightly).

Since the introduction of the 1996 Waste Management Act, the Environmental Protection Agency (EPA) have been responsible for the licensing and control of the majority of the national waste management infrastructure.

Under Section 62 of the Environment Protection Agency Act 1992, the EPA is required to specify and publish criteria and procedures for the selection, management, operation and termination of use of landfill sites. A number of manuals have been published by the EPA, comprising:

- Investigations for Landfills;
- Landfill Monitoring;
- Landfill Operational Practices.

A further manual on Landfill Termination of Use and Aftercare is anticipated in the future but was not available at the time of this assessment.

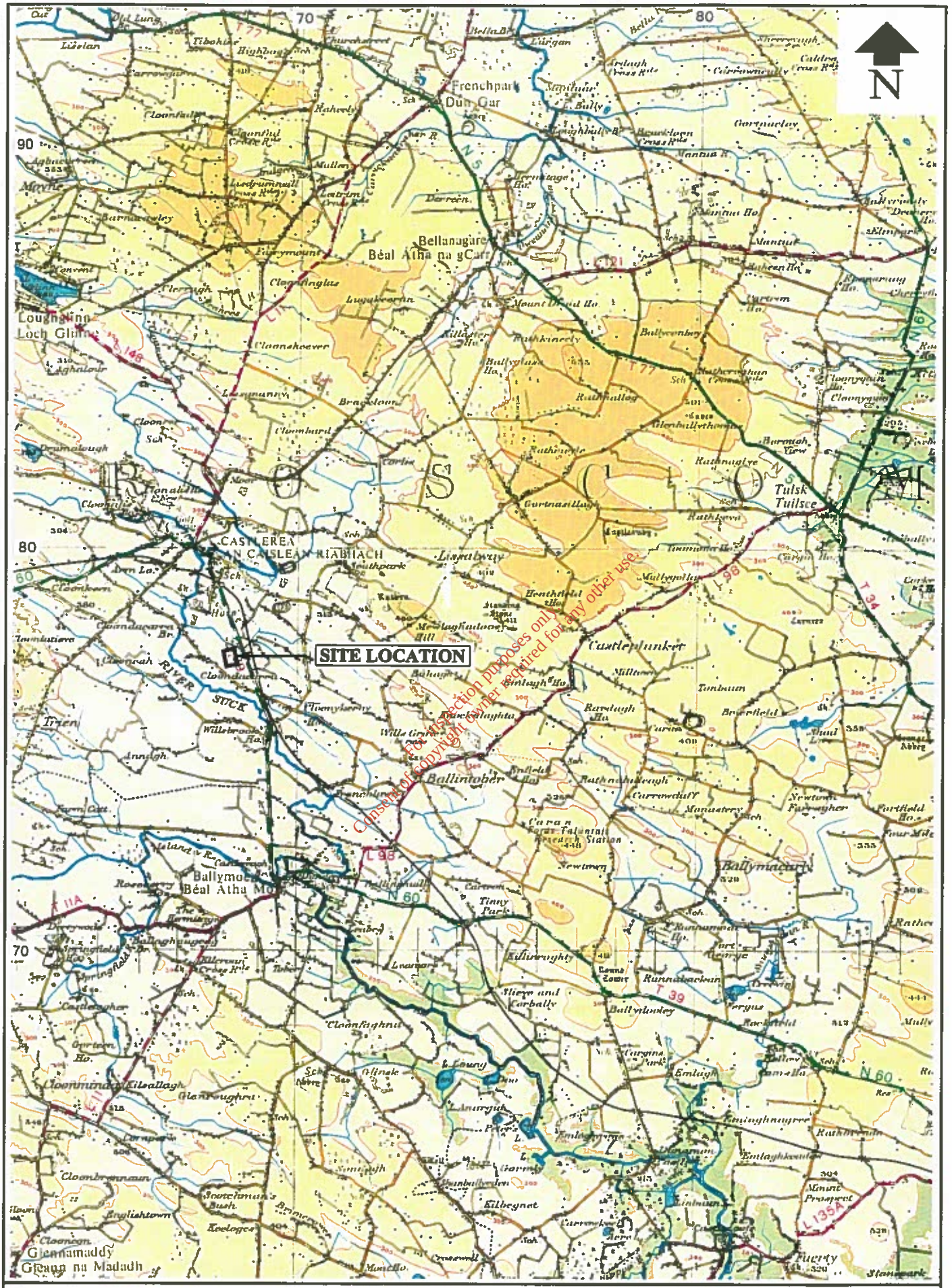


FIGURE 1.1 CASTLEREA LANDFILL
SITE LOCATION MAP

Drawing No: 19428W248 Date: JANUARY 1999 Scale: 1:126 720

Entec

2. SITE INVESTIGATION

2.1 On Site Activities

The site investigation programme of drilling was carried out between 25 August 1998 and 29 August 1998 by Irish Geotechnical Surveys Ltd (IGSL) with supervision by an Entec engineer. Laboratory analysis of samples of surface water, groundwater and leachate collected in September and December 1998 was carried out by Chemical Analysis Laboratory (CAL), Trinity College under contract to Entec. Contact details are given below:

Irish Geotechnical Surveys Ltd
Newbridge
County Kildare

Tel: 00 353 45 431088

Entec UK Ltd
Carrick House
Dundrum
Dublin 14

Tel: 01-2984499

Chemical Analysis Laboratory
Department of Biochemistry
Trinity College
Dublin

Tel: 00 353 1 671 4657

The scope of work comprised the following (locations are shown on Figure 2.1):

i) Drilling of three groundwater monitoring boreholes, numbered CBH3, CBH4 and CBH6, at 150 mm diameter to nominal 8 m depths (to penetrate natural ground) for the installation of a piezometer in each borehole, located as follows:

- northwestern corner of the site to the north of the then current area of tipping;

- northeastern corner of the site between northern limit of the area of older waste and the perimeter drainage ditch;
- southern boundary of the older eastern half of the site.

ii) Drilling of three leachate/gas monitoring boreholes, numbered CBH1, CBH2 and CBH5, at 150 mm diameter to nominal 4 m depths (to the penetrate natural ground below the waste) located within different areas of waste within the site. These boreholes were equipped with 50 mm diameter HDPE casing slotted through the waste.

iii) Collection of disturbed soil samples every metre during drilling, and groundwater or leachate samples collected from each borehole following piezometer installation for analysis for a suite of determinands as specified by the EPA.

iv) Gas monitoring, throughout drilling and following monitoring well installation, for landfill gas.

v) Collection of representative surface water samples from drainage ditches and streams around the site perimeter.

The observation of levels and collection of groundwater, surface water and leachate samples was undertaken in two sampling rounds. The first took place on 30 September 1998 and the second on 3 December 1998. In addition landfill gas monitoring was carried out in leachate/gas monitoring boreholes in December 1998. A levelling survey was undertaken to determine the relative levels of all the boreholes and the topography of the site.

2.1.1 Groundwater Monitoring Wells

Three boreholes, numbered CBH3, CBH4 and CBH6, were drilled by IGSL to depths of between 5 m below ground level (m bgl) and 6.5 m bgl, at the locations shown on Figure 2.1.

Borehole CBH3 was located at the northwestern corner of the site on an area of peat situated approximately 10 m to the north of and around 3 m below the then current tipping face.

Borehole CBH4 was located in the northeastern corner of the old area of waste in the eastern half of the site. Due to the break of slope at the edge of the landfilled waste the

borehole could not be sited directly on natural ground and nearly 4 m of waste had to be drilled through and sealed off, to avoid cross-contamination, prior to completing the borehole in natural ground.

Borehole CBH6 was drilled at the southern end of the eastern area of the site. Again the borehole encountered some landfilled waste which had to be drilled through and sealed off prior to completing the borehole in natural ground.

The following tasks were undertaken during borehole drilling:

- Logging of all drilling returns (Entec).
- Monitoring well construction comprising 63 mm OD HDPE screened casing open within natural ground interval to permit future monitoring and sampling (IGSL).
- Groundwater level monitoring (Entec).

Borehole logs and piezometer construction details are presented in Appendix B.

The approximate elevations of the groundwater monitoring boreholes are presented in Table 2.1, (using an assumed level of 80 m as site datum (SD) at Borehole CBH1.

Table 2.1

Groundwater Monitoring Well Elevations

Monitoring Well	Elevation (m SD)	
	Top of Cover*	Approximate Ground Level
CBH3	77.60	77.31
CBH4	78.90	78.85
CBH6	79.72	79.65

Note:
* Reference for groundwater level monitoring

2.1.2 Leachate/Gas Monitoring boreholes

Three dual purpose leachate and gas monitoring boreholes numbered CBH1, CBH2 and CBH5 were drilled by IGSL at locations within the deposited waste to depths of

between 4 m bgl and 5 m bgl. The boreholes were terminated once 0.5 m of natural ground had been penetrated below the waste.

The following tasks were undertaken during borehole drilling:

- Logging of all drilling returns (Entec).
- Monitoring well construction comprising 63 mm OD HDPE screened casing open over the waste interval to allow future monitoring and sampling. Bentonite seals were installed below the waste to prevent downward migration of leachate (IGSL).
- Leachate level monitoring (Entec).
- Landfill gas monitoring using a portable Analox gas detector (Entec).

Borehole logs and piezometer construction details are presented in Appendix B.

The approximate elevations of the leachate/gas monitoring boreholes are presented in Table 2.2 (based on an assumed level of 80 m as site datum for CBH1).

Table 2.2

Leachate Monitoring Well Elevations

Monitoring Well	Elevation (m SD)	
	Top of Cover*	Approximate Ground Surface
CBH1	80.48	80.00
CBH2 (estimated)	80.30	80.00
CBH5	79.53	79.32

Note:

* Reference for groundwater level monitoring

The elevation for CBH2 had to be estimated as at the time of the levelling survey the borehole had been temporarily buried by more recently deposited waste.

2.1.3 Surface Water

Three surface water samples were taken at locations CSW1, CSW2 and CSW3. The sampling locations were within drainage ditches around the perimeter of the site and are shown on Figure 2.1.

Location CSW1 is to the northwest of the disposal area and downgradient of the site. CSW2 is immediately to the north of the disposal area. CSW3 is upgradient of the disposal site.

2.2 Sampling and Analysis

2.2.1 Soils

Disturbed samples of soil were collected approximately every metre by the drilling contractor and also at horizons of interest. Samples were logged by the Entec Supervising Engineer.

Soil samples were not submitted for chemical analysis.

2.2.2 Groundwater

Groundwater samples were taken from boreholes CBH3, CBH4 and CBH6 using the following procedure:

- Re-usable bailers were installed into the casing below the water level and the borehole was purged by removing three borehole volumes of water.
- Groundwater was then collected in relevant glassware supplied by the laboratory, labelled and stored in cool boxes.
- Bailers were left installed for future use.

Dedicated sampling equipment was used in each borehole to prevent cross-contamination.

Each groundwater sample was analysed for the following determinands:

pH
Electrical Conductivity
Dissolved Oxygen (1st visit only)

Total Dissolved Solids (TDS)
Alkalinity
Major Ions (Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate)
Total Organic Carbon
Metals: Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb), Mercury (Hg), Copper (Cu), Manganese (Mn), Barium (Ba), Nickel (Ni), Selenium (Se), Silver (Ag), Zinc (Zn), Iron (Fe)
Total phosphate
Boron
Cyanide (total)
Fluoride
Total monohydric phenols.

Analytical results are shown in Table 2.3.

Laboratory Certificates of Analysis are shown in Appendix C.

2.2.3 Leachate

Leachate samples were taken from the waste in boreholes CBH1, CBH2 and CBH5 using the following procedure:

- Re-usable bailers were installed into the casing below the leachate level and the borehole purged for three well volumes;
- Leachate was then collected in relevant glassware supplied by the laboratory, labelled and stored in cool boxes;
- Bailers were left installed for future use.

Dedicated sampling equipment was used in each borehole to prevent cross-contamination.

Each leachate sample was analysed for the following determinands:

pH
Electrical Conductivity
Biological Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Alkalinity
Conductivity

Ammoniacal Nitrogen
Major Ions (Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate)
Total Organic Carbon
Total Oxidised Nitrogen
Metals: Hg, Fe, Cd, Cr, Cu, Pb, Mn, Ni, Zn.

Analytical results are shown in Table 2.4.

Laboratory Certificates of Analysis are shown in Appendix C.

2.2.4 Surface Water

Surface water samples were taken from perimeter ditches at locations CSW1, CSW2 and CSW3 (see Figure 2.1) using the following procedure:

- the ditches were cleared of weed in the sampling area and water flow established;
- surface water was then collected in relevant glassware supplied by the laboratory, labelled and stored in cool boxes.

Dedicated single use sampling equipment was used at each surface water sampling location to prevent cross-contamination.

Each surface water sample was analysed for the following determinands:

pH
Electrical Conductivity
BOD
COD
Dissolved Oxygen
Total dissolved solids
Alkalinity
Major Ions (Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate)
Total Organic Carbon
Total Oxidised Nitrogen
Ammoniacal Nitrogen
Metals: Hg, Fe, Cd, Cr, Cu, Pb, Mn, Ni, Zn.

Analytical results are shown in Table 2.5.

Laboratory Certificates of Analysis are shown in Appendix C.

Table 2.3

Castlerea: Groundwater Analyses

Sample Location		CBH3	CBH3	CBH4	CBH4	CBH6	CBH6
Date		30.9.98	3.12.98	30.9.98	3.12.98	30.9.98	3.12.98
Laboratory		CAL	CAL	CAL	CAL	CAL	CAL
Lab Sample No		17113	17758	17114	17759	17116	17760
pH	units	7	6.9	7.3	7	7	7
Dissolved Oxygen	%	27		24		23	
Alkalinity	mg/l	495	335	2550	690	645	450
Conductivity	µS/cm	1142	904	4960	1890	1317	1300
Suspended Solids	mg/l	1762	30000	1183	2312	731	915
Sulphate	mg/l	126	15	23	29	<10	57
Ammoniacal Nitrogen	mg/l	17	8.5	501	136	17.9	1.4
Chloride	mg/l	92	45	90	50	71	74
Total Oxidised Nitrogen	mg/l	0.1	0.23	0.16	0.05	1.42	0.05
Total Organic Carbon	mg/l	22	98	120	21	19	17
Arsenic	mg/l	0.024	<0.005	0.012	0.007	<0.005	<0.005
Barium	mg/l	0.2	0.21	0.15	0.09	0.21	0.31
Boron	mg/l	0.16	<0.05	0.97	0.23	0.16	<0.05
Cadmium	mg/l	<0.005	<0.005	<0.05	<0.005	<0.05	<0.005
Chromium	mg/l	0.03	<0.01	<0.03	<0.01	<0.03	<0.01
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	µg/l	0.07	<0.02	<0.02	<0.02	<0.02	<0.02
Copper	mg/l	0.05	<0.01	0.04	<0.01	<0.01	<0.01
Nickel	mg/l	0.12	<0.03	0.04	0.05	<0.03	<0.03
Zinc	mg/l	0.15	0.01	0.05	0.02	0.1	0.16
Manganese	mg/l	0.2	0.12	0.9	1.37	0.77	2.1
Total Phosphate	mg/l	0.14	<0.1	1.07	<0.1	<0.1	<0.1
Selenium	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/l	10.2	0.49	9.3	9.3	0.85	3.37
Total Monohydric Phenols	mg/l	0.08	0.08	0.07	0.1	0.05	<0.05
Cyanide (Total)	mg/l	<0.025	<0.01	<0.025	<0.01	<0.025	<0.01
Fluoride	mg/l	0.21	0.14	0.15	0.11	0.06	0.1
Magnesium	mg/l	6.85	4.16	71.7	31.3	18	19.1
Sodium	mg/l	120	23.7	140	23.6	89	78
Calcium	mg/l	146	193	189	200	151	221
Potassium	mg/l	9.92	3.26	68	25.8	7.91	6.4

Table 2.4

Castlerea: Leachate Analyses

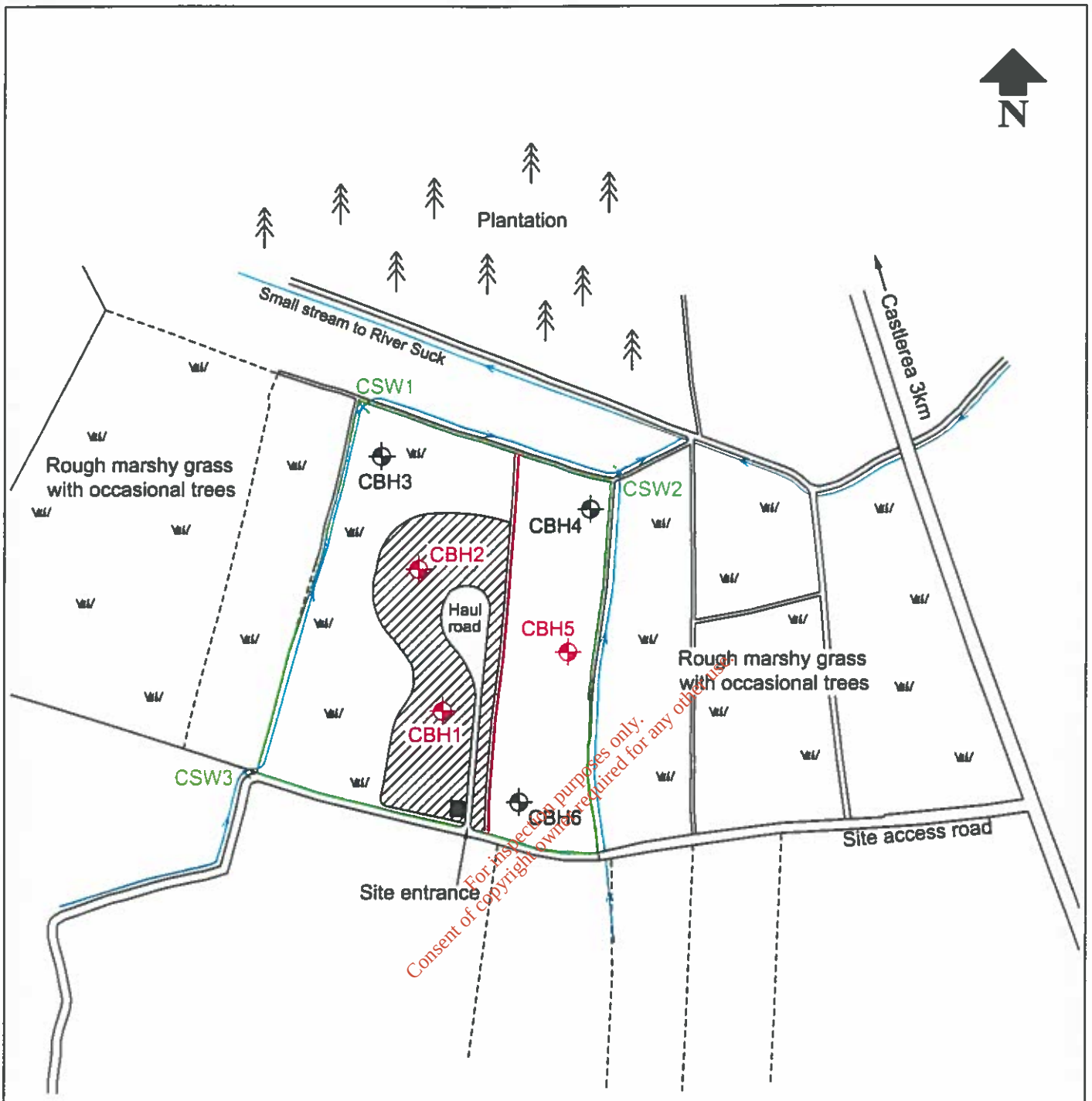
Sample Location		CBH1	CBH1	CBH2	CBH5	CBH5
Date		30.09.98	03.12.98	30.09.98	30.09.98	03.12.98
Laboratory		CAL	CAL	CAL	CAL	CAL
Lab Sample No		17131	17751	17132	17133	17752
pH	units	7.5	7.6	7.3	7.7	7.6
BOD	mg/l	925	450	300	82.5	35
COD	mg/l	4494	3301	2492	722	291.8
Alkalinity	mg/l	7800	1170	4550	4700	1625
Conductivity	µS/cm	15720	21900	2290	9530	5470
Ammoniacal Nitrogen	mg/l	1836	52	641	831	48
Chloride	mg/l	2080	36.2	6490	774	710
Sulphate	mg/l	103	1610	42	91	351
Total Oxidised Nitrogen	mg/l	0.13	0.48	0.37	0.22	0.07
Total Organic Carbon	mg/l	950	650	350	190	64
Cadmium	mg/l	0.007	<0.005	<0.005	<0.005	<0.005
Chromium	mg/l	<0.03	0.02	<0.03	<0.03	<0.01
Lead	mg/l	<0.05	<0.05	<0.05	0.05	<0.05
Mercury	µg/l	<0.02	<0.02	0.05	0.1	<0.02
Copper	mg/l	0.03	0.02	0.07	0.05	<0.01
Nickel	mg/l	0.08	0.11	0.03	0.05	0.22
Zinc	mg/l	0.2	0.06	0.36	0.27	0.01
Manganese	mg/l	0.56	0.02	0.98	0.88	0.41
Iron	mg/l	3.46	1.99	8.7	11	0.94
Magnesium	mg/l	140	113	293	92.7	93.4
Sodium	mg/l	1400	1400	3500	460	170
Calcium	mg/l	191	10.7	415	58.7	61.2
Potassium	mg/l	420	1100	460	220	450

Table 2.5

Castlerea: Surface Water Analyses

Sample Location		CSW1	CSW1	CSW2	CSW2	CSW3	CSW3
Date		30.09.98	03.12.98	30.09.98	03.12.98	30.09.98	03.12.98
Laboratory		CAL	CAL	CAL	CAL	CAL	CAL
Lab Sample No		17122	17732	17123	17733	17124	17734
pH	units	8	7.9	7.6	7.6	7.6	7.6
BOD	mg/l	<10	32.5	<2.5	3.5	<1.0	<1
COD	mg/l	1448	775.3	189.5	85.8	70.9	70.4
Dissolved Oxygen	%	43	12	22	29	54	75
Alkalinity	mg/l	3650	2700	640	810	240	148
Conductivity	µS/cm	10540	8250	1802	2030	478	360
Suspended Solids	mg/l	900	NT	130	NT	12.6	NT
Sulphate	mg/l	48	63	46	24	14	15
Ammoniacal Nitrogen	mg/l	591	618	61	118	0.3	0.1
Chloride	mg/l	1880	1200	235	167	27	22
Total Oxidised Nitrogen	mg/l	0.38	0.33	0.87	0.72	0.12	3.54
Total Organic Carbon	mg/l	410	330	97	32	31	25
Cadmium	mg/l	0.006	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	mg/l	0.06	0.04	<0.03	<0.01	<0.03	<0.01
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Mercury	µg/l	0.04	0.02	0.05	0.09	<0.02	0.29
Copper	mg/l	0.04	<0.01	0.01	<0.01	<0.01	<0.01
Nickel	mg/l	0.05	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	mg/l	0.15	0.06	0.03	0.03	<0.01	0.01
Manganese	mg/l	0.15	0.21	0.52	0.17	0.7	0.02
Iron	mg/l	1.18	0.81	1.23	0.3	0.69	0.32
Magnesium	mg/l	76.6	59.8	31.4	37.3	4.46	3.37
Sodium	mg/l	900	620	130	100	12.6	9.5
Calcium	mg/l	170	120	112	126	96.9	71
Potassium	mg/l	400	220	46.2	37.8	1.28	1.41

Note:
NT = Not Tested



KEY

- Original landfill site (closed) - AREA A1
- Recent filled area - AREA A2
- Groundwater monitoring borehole
- Gas / leachate sampling borehole
- Surface water sampling pont
- Marshy area
- Fenced site boundary
- Ticket office
- Drainage ditch with directional flow

FIGURE 2.1 **CASTLEREA LANDFILL - GROUNDWATER, SURFACE WATER AND LEACHATE SAMPLING LOCATIONS**

Drawing No: 19428W249 Date: JANUARY 1999 Scale: 1:2500 Approx.

Entec

3. SITE DESCRIPTION AND SITE INVESTIGATION RESULTS

3.1 Location

Castlerea Landfill site is located 3 km to the south of the centre of the town of Castlerea, County Roscommon, at National Grid Reference 168360 277500 (see Figure 1.1).

The site lies immediately to the south of an east-west flowing tributary of the River Suck. The topography of the surrounding area is generally fairly flat and lies at an elevation of around 80 m AOD sloping at low gradients towards the tributary of the River Suck immediately to the north. The topography of the site itself comprises a raised area in the centre of the site made up of landfilled waste. This raised area rises 2-3 m above the natural ground and slopes down to ditches around the site perimeter.

The site is bounded to the north by a strip of rough grazing land separated by a small stream, flowing in a straightened ditch like channel, from a coniferous plantation beyond. To the east and west the site is bound by rough open bogland with occasional young conifers and to the south by the site access road beyond which is rough agricultural land. The site entrance is approached via a minor road off the main N60 road between Castlerea and Ballymoe to the south.

3.2 Site Layout

The layout of the site in August 1998 is shown in Figure 3.1. The site covers a total area of 4.05 ha of which 1.35 ha were filled and partly restored and covered in 1997 in the eastern phase (A1), 1.15 ha form the area presently used for landfilling in 1998 (A2), and approximately 1.55 ha remain unfilled. Filling most recently took place in the northern and central part of the western half of the site. At the time of the site investigation (August 1998) the A2 phase was being covered.

The site is nominally divided into 2 phases as shown on Figure 2.1. The eastern phase (A1) forms the previously landfilled area which was operational between 1960 and 1988. This phase is currently grassed over and is elevated by 2 to 3 m above the land surface to the east.

The western phase of the site (A2), the most recent area of landfilling, is separated from the eastern phase by both a fence and earth bund. The most recent area of tipping

was the northern and central parts of the western phase which are elevated by 2 to 3 m above the land surface to the west.

3.3 Site History

Details of the site's history have been obtained from discussions with staff from Roscommon County Council including the Environmental Engineer, the Area Engineer, and the Site Operator. Prior to the use of the site for landfill the land is believed to have been low grade agricultural land.

The site was originally used for landfill in the mid 1960's with the first waste deposited in the southern end of the eastern half of the site. Waste tipping in this area continued until 1988 when it then continued in the western half.

3.4 Landfill Operations

3.4.1 Landfill Design and Operational History

The Roscommon County Council 'Draft Waste Management Plan (1995 to 2000)' provides information on operational practices at Castlerea Landfill.

The landfilling operation consisted of land raise deposition of waste with compaction using a tracked vehicle. The waste was deposited in crude cells though there was no formal operational plan or design for the site.

The area of the landfill is generally underlain by peat. The peat may have been removed in places prior to deposition of waste.

The landfill received a total of 3090 tonnes of waste during 1994 of which around 80% comprised domestic waste, 19% commercial waste and 1% of waste derived from the County Council (sewage treatment sludge).

The typical contents of domestic waste in Roscommon County comprised 46% organic material, 21% paper, 9% plastics and around 9% cinders, minor components included glass, metal, nappies, textiles and other materials.

Castlerea landfill is known to have also accepted dog carcasses from the local dog pound.

Details of the landfilling operations for each area of the site are poorly constrained, but the approximate periods of filling of the different areas are shown in Table 3.1.

Table 3.1

Details of Landfilling Operations

Phase	Area (ha)	Design	Dates of Waste Disposal[a] Start	End	Covered[b]
A1	1.35	land raise	1960's	1988	by 1997
A2	1.15	land raise	1988	1998	1998/99

Notes:
a: Dates are approximate only.
b: Temporary cover only.

Since 1992 charges for waste disposal have been in force at all Roscommon County Council landfill sites.

Roscommon County Council has provided the numbers of each type of load accepted at the site during 1997 and 1998. These data show that approximately half of the waste deposited was made up of domestic waste brought to site in refuse collection vehicles with the other half comprising smaller loads. The data are reproduced in Appendix A.

3.4.2 Thicknesses of Waste

The leachate/gas monitoring boreholes (CBH1, CBH2 and CBH5) were drilled within waste in Areas A1 and A2. These boreholes encountered 3.00 m, 0.90 m and 3.20 m of waste, overlain by 0.70 m, 0.20 m and 0.40 m of locally derived Boulder Clay capping respectively. It is likely that waste thicknesses increase to the north, 3.80 m thickness was found at CBH4. From the borehole evidence and visual inspection of the site it is estimated that waste thickness is on average 3.5 m over area A1 and 2 m over area A2, this gives a total of around 70 000 m^3 of waste present on site.

The base of the waste was found to rest on peat in boreholes CBH1, CBH2 and CBH5. Waste was encountered lying directly above Boulder Clay in CBH4. It is therefore likely that a layer of peat underlies most of the waste at the site.

3.4.3 Leachate Management

The site is now closed to further waste disposal. Preparations for covering with a cap of Boulder Clay are currently underway.

At the time of the site works no leachate or landfill gas management measures were in place. An estimate of the volume of leachate generated can be made by considering the area of landfill wastes and the climatic regime. Landfill wastes occupy an area of approximately 2.5 ha. Effective rainfall has been estimated as 681 mm/annum (Section 3.5.1). Assuming no runoff from uncapped permeable waste an estimated 17 000 m^3 of leachate will be generated per annum.

The placing of a low permeability cap over the site will reduce the amount of infiltration and promote runoff. With 0.5 m of compacted Boulder Clay cover infiltration is expected to reduce to around 30% of the value giving an estimated leachate production of 5700 m^3/annum (based on an average infiltration of 1 mm/day for the 178 days when rainfall exceeds 1 mm, see Appendix C).

During site investigations it was noted that leachate had ponded in two areas of the western half of the site (Figure 3.1). These comprised an area in the northwestern corner of Area A2 where leachate was ponded in a lagoon covering approximately 150 m^2. This lagoon has an estimated depth of 0.5 to 1.0 m. The lagoon is situated to the north and west of the more recent waste tipping area. Leachate was observed to flow directly from the waste into the lagoon (see Figure 3.1).

Further leachate had accumulated in a series of interconnected ponds along the western edge of the waste deposited in area A2 (Plate 3.1). These ponds received leachate directly from the base of the waste and discharge into the perimeter drainage ditch running along the western site boundary (Plate 3.2), close to monitoring point CSW2, as well as infiltrating directly into the surrounding peat. The impact of this leachate on surface water quality is discussed in Section 4.

Leachate composition lies within typical ranges quoted for domestic waste (see EPA Landfill Operational Practice Manual). Many determinands are found at concentrations above typical mean concentrations, indicating a relatively young leachate. Over time the principal contaminants would be expected to decline in concentration within the leachate.

3.4.4 Landfill Gas

Measurements of landfill gas concentrations were taken during a site visit in December 1998 and these are given in Table 3.2.

Table 3.2

Gas Monitoring Results

Borehole	Survey Date	Borehole Depth (m bgl)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	Atmos (mbar)	Pressure
CBH1	2/12/98		24.2	10.1	11.3	1026	
CBH2	2/12/98	buried					
CBH5	2/12/98		72.7	6.4	12.3	1026	

These results show that methane (CH_4) and carbon dioxide (CO_2) are present at elevated concentrations. The proportions in which they are found and presence of oxygen suggest aerobic degradation of waste as would be expected in a poorly compacted (therefore well ventilated) land raise.

3.5 Hydrology

3.5.1 Meteorological Data

Meteorological data have been obtained for the Irish Meteorological Service station located at Claremorris approximately 35 km to the southwest of the site. These comprise the following:

- wind rose and wind frequency tables, based on an analysis of mean hourly wind speeds and directions for the period 1961 to 1990;
- tables of estimated maximum falls of rain for a range of durations and return periods;
- a climatological data sheet for the period 1961 to 1990 containing monthly and annual mean and extreme values of the main weather elements.

This data is reproduced in Appendix D.

In addition continuous daily rainfall readings, from July 1986 to August 1998, have been obtained for the rainfall station at Frenchpark located approximately 14 km to the north of the site.

Further climatological information has been obtained from the Water Quality Management Plan (WQMP) for the Upper Shannon Catchment which contains an isohyetal map (rainfall contours) of the Shannon Catchment based on long term average annual rainfall measured at a number of rainfall stations.

The mean annual rainfall measured at Claremorris over the period 1961 to 1990 was 1143 mm with a maximum daily value of 74.6 mm. The mean monthly totals vary from 62.3 mm in April to a high of 124.6 mm in October with the majority of rainfall between October and January. Rainfall exceeds 5 mm/day for an average of 78 days per year and exceeds 1 mm/day for 178 days.

The mean annual rainfall measured at Frenchpark over the period 1987 to 1997 was 1157.5 mm, with a similar monthly distribution to that measured at Claremorris.

Data contained within the Upper Shannon Catchment WQMP (1990) states average annual rainfall measured at Willsbrook (some 2 km south of the site) as 1080 m. Therefore using an average of these three readings the average annual rainfall at the Castlerea Landfill site has been taken as 1128 mm/annum.

Actual evaporation has been estimated for the Castlerea site at 447 mm/annum. This is based on figures obtained for Willsbrook monitoring station in the Upper Shannon WQMP. In this report a long term average runoff figure is calculated which represents the difference between the long term average rainfall and evapotranspirative losses. The figures quoted for Willsbrook comprise 1080 mm/annum (long average rainfall) and 633 mm/annum (long average runoff) thereby giving an estimate of evapotranspiration as 447 mm/annum. From these data it is inferred that approximately 681 mm/annum of rainfall is available to infiltrate or runoff the landfilled waste.

3.5.2 Drainage

The site is situated immediately south of a small tributary of the River Suck. This tributary drains into the Suck around 1.3 km to the west of the site at Cloondacarra Bridge. The tributary rise in hills to east at Bohagh and flows westwards. It has a catchment area of approximately 10 km^2. The River Suck flows to the east and southeast eventually discharging into the River Shannon at Shannonbridge some 65 km to the southeast. The WQMP estimates that the catchment of the River Suck at Willsbrook, 2 km to the south of the Castlerea site to be 182 km^2. Thus the unnamed tributary into which the landfill drains contributes approximately 6% of the total catchment of the Suck.

Local drainage around the site consists of perimeter drainage ditches on the western and eastern sides. These conduct drainage northwards and discharge into another drainage ditch flowing eastwards along the northern boundary of the site. This ditch discharges into the stream to the north of the site which then flows to the River Suck. Both the western and eastern perimeter drainage ditches drain agricultural land to the south of the site prior to receiving site drainage. This landfill occupies close to 0.25% of the catchment of the stream to the north of the site.

During site investigations in August flow in the western and eastern perimeter ditches was measured to be less than one litre per second, with the flow in the northern ditch at around one to two litres per second.

3.5.3 Surface Water Quality

Information on river flows in the area around Castlerea have been derived from the Water Quality Management Plan for the Upper Shannon Catchment (1990).

The River Suck forms the principal tributary to the Upper Shannon with a total catchment area of 1600 km^2. The Suck rises some 11 km to the west of Castlerea and initially flows into Lough O'Flynn, 9 km to the west of Castlerea, prior to flowing eastwards into Castlerea itself.

Around 6 km to the north of Castlerea the Francis River rises. This discharges into the Cloonard River which flows south into Castlerea where it joins the River Suck upstream of the landfill.

The Francis River and Cloonard River are not gauged. The River Suck, however, is gauged at Willsbrook 2 km to the south of the site with a 95 percentile flow of 0.30 cumecs[1] and an estimated minimum dry weather flow of 0.20 cumecs. On reaching Castlerea the River Suck has only drained 9% of its total catchment area whereas downstream at Ballinasloe, where 90% of the catchment area has contributed to flows, the 95 percentile flow is gauged at 2.3 cumecs with an estimated dry weather flow of 1.0 cumecs.

Water quality has been assessed in all three rivers by means of biological and physico-chemical methods.

The River Francis was surveyed in 1984 and classified as doubtful to fair quality (classes Q3 to Q4) along 1.8 km of surveyed channel length. The Cloonard River was

[1] (1 cumec ≡ 1000 l/sec)

also surveyed in 1984 and received a good or fair quality assessment (classes Q4 to Q5) along a surveyed channel length of 8.1 km. The water draining into the River Suck upstream of Castlerea can therefore be assumed to be unpolluted and of good quality.

The quality in the River Suck was assessed in 1983 and 1984 along a total of 109 km of the river channel. The results indicated that the Suck was of good or fair quality (classes Q5 and Q4) along 89.9 km of the channel length, and of doubtful to fair quality (Q3 to Q4) along 19.1 km. The deterioration in water quality in the Suck occurs in its lower reaches where problems of peat siltation are apparent. In the area around Castlerea the River Suck is of good quality.

Details of the physico-chemical quality results reported for the Rivers Francis, Cloonard and Suck are provided in Table 3.3.

Table 3.3

River Water Quality Data

River	No of samples	Dissolved Oxygen (% saturation)	BOD (mg/l)	Ammonia (mg/l)	Total Oxidised Nitrogen (mg/l as N)	Orthophosphate (mg/l as P)
Francis	1	90	1.7	0.02	0.48	0.02
Cloonard	2	117 - 121	1.9 - 2.5	0.04 - 0.07	0.5 - 0.93	0.02 - 0.03
Suck	15	83 - 93	1.5 - 2.0	0.03 - 0.08	0.4 - 0.91	0.01 - 0.04

The WQMP also gives a waste assimilation capacity (WAC) for each watercourse based on the capacity of a river to assimilate waste principally by dilution but also by chemical or biological modification of pollutants. The River Suck WAC value was calculated at Castlerea as 52 kg BOD/day while the load discharged from the town's activated sludge treatment works is estimated at 20 kg BOD/day.

In the vicinity of the site, surface water has been assessed by means of samples taken at three locations (CSW1, CSW2 and CSW3). The location of these points is shown on Figure 2.1. CSW1 lies immediately downstream of the site in direct contact with leachate ponds. CSW2 further downstream at the point where the eastern and western perimeter drains meet. CSW3 is upstream of the site to the south.

The results of surface water sampling are shown in Table 2.5.

The results show that:

- CSW1 and CSW2 show the dominant influence of leachate on surface water quality immediately around the site with elevated COD, conductivity, ammoniacal nitrogen concentration and low dissolved oxygen content.
- There is an improvement in water quality from CSW1 to CSW2 with concentrations of major contaminants being in general 4 to 5 times lower at CSW2
- There is a general improvement in water quality, shown by reduced contaminant concentrations, in CSW1 and CSW2 between September and December, possibly due to increased rainfall and consequent dilution.
- CSW3 is upstream of the landfill and is comparable to the river water given in Table 3.3, although dissolved oxygen is somewhat lower than the previous river water samples. Total oxidised nitrogen is particularly high in December.
- Background water quality, as found at CSW3 shows water to be of a calcium bicarbonate type with low total dissolved solids.

3.5.4 Surface Water Abstractions

Water is abstracted for public water supply at Ballinasloe 20 to 30 km downstream of the site. An abstraction of 2750 m^3/d is recorded.

3.6 Geology

3.6.1 General Setting

The regional geology of the area around the Castlerea Landfill site is illustrated on Figures 3.2. This regional information was obtained from the records of the Geological Survey of Ireland.

The site is situated on peat overlying Boulder Clay deposits (Glacial Till) situated on Carboniferous Oakport Limestone bedrock. A borehole within 500 m of the site (GSI Records) records around 12 m of Boulder Clay prior to encountering a thin layer of limestone pebbles overlying the Oakport Limestone. The limestone itself is karstic and is a recognised regionally important aquifer.

3.6.2 Site Details

More detailed information on the shallow geology beneath the site is provided in geological logs of boreholes constructed at the site (Appendix B). Locations of these boreholes are shown on Figure 2.1.

The strata encountered during drilling at the Castlerea Landfill site indicate that the majority of the landfill is underlain by a layer of peat over Boulder Clay. Peat was encountered in every borehole except CBH4 at the northern end of the eastern area of the site, where peat may have been dug out to allow more void space for filling and waste sits directly on Boulder Clay.

Borehole CBH3 was drilled in natural ground with peat at the surface and extending to a thickness of 3.6 m prior to intersecting Boulder Clay. This is believed to be representative of the original thickness of peat present over the site. The boreholes drilled through waste encountered peat of around 2 m thickness suggesting that a proportion of the original peat layer was dug out prior to commencing landfill operations or that landfilling has effectively consolidated the peat.

Boulder Clay was encountered throughout the site either beneath landfilled waste or peat. A maximum thickness of 1.8 m was penetrated. The Boulder Clay was never fully penetrated and is believed to be in the order of 12 m thick overlying the Oakport Limestone bedrock.

The Boulder Clay is grey and grey/brown and silty to very silty clay with occasional gravel, cobbles and boulders of limestone.

3.7 Hydrogeology

3.7.1 Water Table Elevation

Shallow groundwater was encountered within the peat and Boulder Clay deposits in boreholes CBH3 and CBH6. The depth to groundwater varied between 0.9 m bgl (CBH3) and 2.2 m bgl (CBH6). Groundwater levels rose slowly within these boreholes following water strikes. This slow response may confirm the low hydraulic conductivity of the Boulder Clay and peat.

The Oakport Limestone is a major aquifer and feeds springs at Castlerea and Longford 2.5 km and 1.0 km to the northwest respectively. The groundwater level in the Oakport Limestone beneath the site is not known. Groundwater flow in the limestone probably follows the topography and therefore would be expected to be from the

northwest to the southeast. The springs at Castlerea and Longford represent major natural discharge points of the aquifer at higher topographic levels than (upgradient of) the site.

3.7.2 Hydraulic Properties

Hydraulic conductivity values of peat are reported to be highly variable depending on botanical composition, humification, bulk density, fibre content, porosity and surface loading as well as the depth within the peat itself (Hobbs, 1986). The upper 0.6 m of bogland peat is reported as having hydraulic conductivities in the order of 3×10^{-5} m/s with values decreasing to around 3×10^{-8} m/s as the depth and density increases (Hobbs, 1986). Peat is known to be anisotropic with higher horizontal permeability due to the parallel alignment of the plant fibres within the peat providing preferential horizontal flowpaths.

Boulder Clay directly underlies the northern end of the eastern area of the landfill and lies beneath the peat elsewhere under the landfill. The Boulder Clay generally comprises a soft to moderately firm, silty to very silty clay with occasional gravelly horizons and pebbles to boulders of the underlying limestone bedrock. Typical values of hydraulic conductivity for Boulder Clay are in the range of 10^{-6} m/s to 10^{-12} m/s, though in the sandy horizons may reach 10^{-3} m/s (Freeze and Cherry, 1979). It is likely that horizontal hydraulic conductivity values of the Boulder Clay in the region of the Castlerea site are in the order of 10^{-7} to 10^{-8} m/s, as it contains a relatively high proportion of silt and clay. Vertical hydraulic conductivities will be at least one order of magnitude lower.

3.7.3 Groundwater Flow

3.7.3.1 Boulder Clay

Little information on groundwater flow in the Boulder Clay is available. The elevation of the water table has been measured on two occasions in the three groundwater monitoring wells. These indicate a hydraulic gradient of 0.005 to the north-northwest, towards the unnamed tributary of the River Suck.

3.7.3.2 Oakport Limestone

The Oakport Limestone is classified as a regionally important fractured bedrock aquifer (Rf) in the terminology of the Geological Survey of Ireland (Daly, 1997). The limestone is characterised by fracture dominated flow with little or no likelihood of

attenuation of contaminants once they have penetrated any overlying strata. Groundwater within the aquifer is therefore potentially vulnerable to contamination.

Gradients in the Oakport Limestone probably form a subdued expression of the surface topography and therefore to be from high ground to the northeast towards the River Suck. The springs at Castlerea and Longford form major discharge points for groundwater flow. The Oakport Limestone is karstic and therefore flow is likely to be concentrated in a small number of solution enhanced fissures with relatively high flow velocities.

3.7.4 Groundwater Quality

Groundwater in the peat and Boulder Clay was sampled from boreholes CBH3, CBH4 and CBH6 and the results are shown in Table 2.3.

CBH6 is upgradient of much of the site and therefore is probably closer to background groundwater quality than the other wells. However, even this borehole shows signs of leachate contamination in the form of elevated concentrations of ammoniacal nitrogen, chloride and sodium. Groundwater is of a calcium bicarbonate type with elevated sodium chloride.

CBH3 and CBH4 show contamination from leachate which is particularly evident at CBH4 located immediately downgradient of the older eastern phase. Groundwater in this well gives high concentrations of ammoniacal nitrogen and TOC. CBH3 shows overall lower concentrations of dissolved species.

Well CBH4 is probably sampling leachate directly and is therefore not representative of groundwater quality beneath the site.

The quality of groundwater from the Oakport Limestone has not been measured as part of this study but is likely to be good as it is used for public water supply.

3.7.5 Groundwater Abstractions

Groundwater is exploited in the region via springs. The Oakport Limestone supports springs at Castlerea (NGR M 700 795) and Longford (NGR M 693 785). These lie approximately 2.5 km and 1.0 km to the northeast of the site at elevations close to 100 m OD respectively. Approximately 1727 m^3/day is abstracted for water supply at Castlerea and 1600 m^3/day at Longford.

3.7.6 Groundwater Vulnerability

The Geological Survey of Ireland guidelines classify aquifer vulnerability according to sub-soil type and thickness over the groundwater resource. This vulnerability rating assumes that contaminants are released 1 to 2 m below ground level. Castlerea Landfill rests on subsoil made up of 2 to 3 metres of peat overlying a considerable thickness of Boulder Clay which is underlain by the Oakport Limestone. The vulnerability rating for the limestone aquifer in these circumstances is R2 (the lowest category) (Daly, 1997).

3.8 Leachate Levels and Quality

3.8.1 Leachate Levels

Leachate levels, as measured in boreholes CBH1 to CBH3 during August 1998, varied between 3.42 m bgl and 3.53 m bgl. Leachate levels over much of the site are coincident with the water table, indicating that there is little mounding within the waste. In the western part of the landfill leachate levels are 0.2 m above estimated water table elevations.

3.8.2 Leachate Vertical Leakage Rates

The rate of potential leachate leakage to the underlying Oakport Limestone can be estimated. Assuming that the Boulder Clays have a thickness of 12 m beneath the site and that the Oakport Limestones are probably confined beneath Boulder Clay with a standing water level within 3 to 4 m of the ground surface the vertical hydraulic gradient, i, is likely to be in the order of 1 m in 12 m (0.1). Vertical hydraulic conductivity, K_v, for the Boulder Clay is likely to be in the range 10^{-8} to 10^{-9} m/s. Vertical hydraulic conductivity is considered to be an order of magnitude lower than horizontal hydraulic conductivity due to the anisotropic nature of most strata.

Using Darcy's Law ($Q = K_v iA$), the vertical leakage of leachate, Q, from the site of approximate area, A, of 2.5 ha is estimated as between 2.5×10^{-6} and 2.5×10^{-5} m^3/s. These leakage rates equate to an input from the site of between 3 and 30 mm/annum (10-100 m^3/annum). Given the effective rainfall over the site (estimated at 681 mm/yr) this estimate indicates that movement of leachate into the Boulder Clay to the Oakport Limestone is a minor component of the effective rainfall. The generally waterlogged nature of the area around the landfill area and the presence of a shallow perched water table also suggest that vertical drainage is limited and it is therefore likely that the lower limit of the estimate is closer to the actual situation.

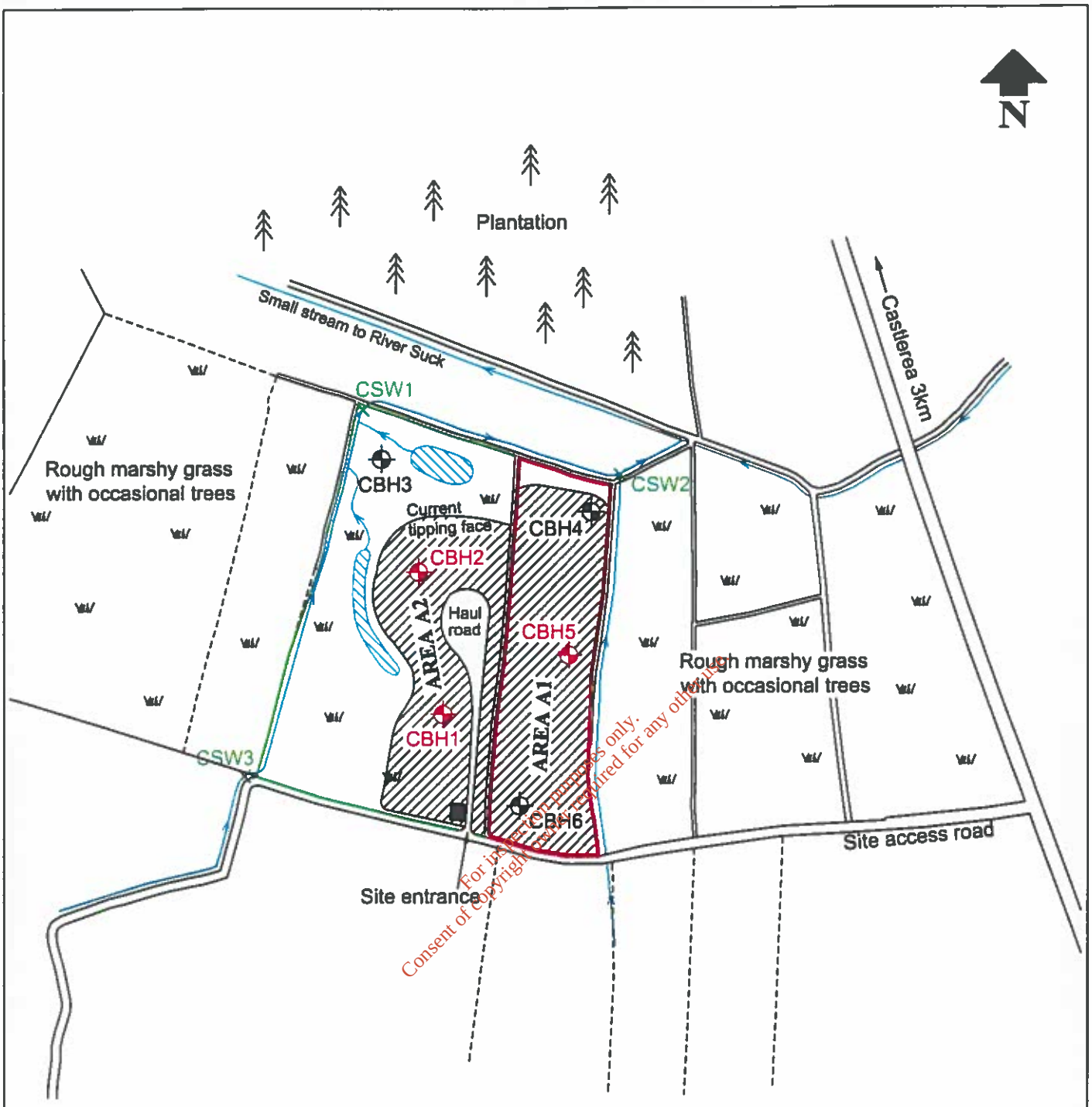
Travel times for leachate leaking through the 12 m of Boulder Clay assuming K_v between 10^{-8} and 10^{-9} m/s, i equal to 0.10 and porosity, n of 0.10 to 0.20 and using a groundwater velocity ($v=K_v i/n$) of 0.300 to 0.015 m/yr are in the 40 to 800 year range.

3.8.3 Leachate Quality

Leachate quality data for samples collected from boreholes CBH1 to CBH3 are given in Table 2.4.

CBH5 in the older capped phase shows generally lower concentrations of most determinands, with the exception of metals. CBH1 is particularly elevated with respect to BOD and COD and TOC. CBH2 lies between CBH1 and CBH5 in its composition, although it does contain unusually high concentrations of sodium chloride. The waste surrounding CBH5 will be the oldest of that sampled and therefore represents a more mature leachate. Leachate concentrations are highly variable between the two sampling periods, with much higher concentrations recorded in December than September. This may reflect seasonal changes in microbial activity within the waste or may be due to dilution. Peat (in northern Scotland) has previously been determined to result in a COD in peat water of up to 544 mg/l (Foundation for Water Research, 1994). A proportion of the COD may therefore result from peat rather than leachate.

In general the composition of leachate is within the range of compositions seen at other landfill sites receiving domestic and industrial wastes (Robinson, 1995).



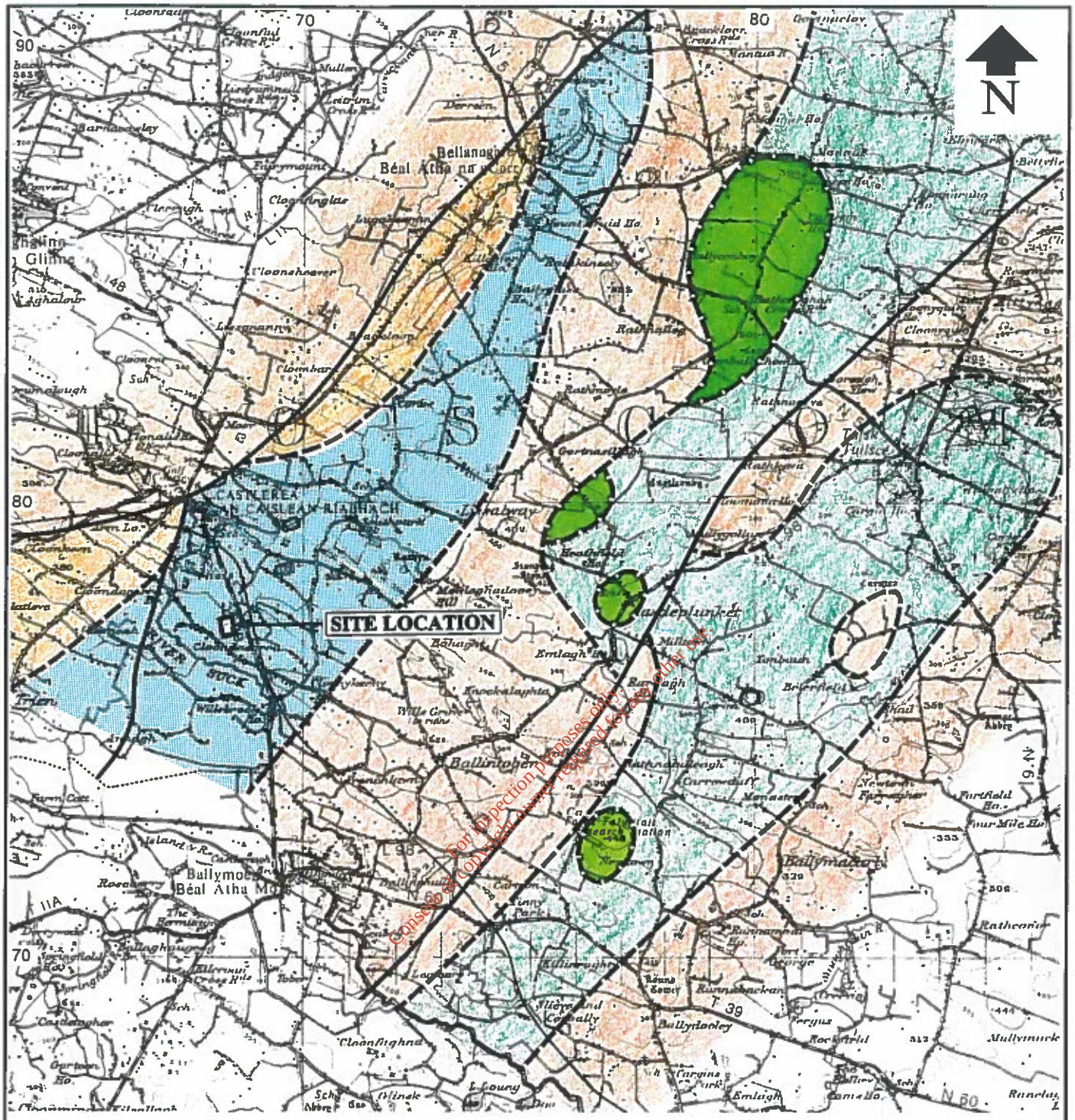
KEY

- Original landfilled site (closed) - AREA A1
- Recent landfilled area - AREA A2
- Groundwater monitoring borehole
- Gas / leachate sampling borehole
- Surface water sampling pont
- Marshy area
- Fenced site boundary
- Ticket office
- Drainage ditch with directional flow
- Ponded leachate

FIGURE 3.1 CASTLEREA LANDFILL SCHEMATIC SITE LAYOUT

Drawing No: 19428W250 Date: JANUARY 1999 Scale: 1:2500 Approx.

Entec



KEY

- Croghan Oolite
- Croghan Limestone
- Ballymore Limestone
- Oakport Limestone
- Boyle Sandstone

} Carboniferous

FIGURE 3.2 REGIONAL BEDROCK GEOLOGY AROUND CASTLEREA LANDFILL

Drawing No: 19428W251 Date: JANUARY 1999 Scale: 1:126 720

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4. RISK ASSESSMENT

4.1 Risk Assessment Approach

The standard approach to risk assessment is to ascertain the HAZARDS created by the possible PATHWAYS through which these hazards might migrate from the site and the TARGETS to which these pathways provide access. Risks to surface water and groundwater from leachate and to the environment from landfill gas from the Castlerea Landfill site are those identified.

For a risk to be present there must be a hazard, a target or receptor and a pathway linking the two. For example, for there to be a risk to a groundwater target, leachate (the hazard) must be able to move by groundwater flow (the pathway) from the waste within the landfill. For groundwater flow to occur there must be a difference in pressure head and flow occurs from the higher to the lower pressure head.

4.2 Hazards

For the Castlerea Landfill site the principal hazard identified from these investigations arise from the generation of landfill leachate. In view of the relatively remote site location landfill gas is a secondary hazard.

4.3 Pathways

The principal pathway for leachate is surface drainage from the site towards and into the tributary of the River Suck. There is also a possible pathway through the Boulder Clay to the underlying Oakport Limestone. Leachate can reach surface water bodies either directly as overland flow to drainage ditches or via shallow groundwater.

Landfill gas can migrate through the unsaturated zone via air filled voids and can potentially impact of the safety of the nearest structure. At Castlerea Landfill site the unsaturated zone is thin (less than 2 m) and therefore the potential for migration is limited.

4.4 Targets

4.4.1 Background

Targets can be as specific as licensed groundwater abstractions, springs or rivers receiving drainage baseflow downgradient of the site or as non specific as geological strata identified as aquifers.

4.4.2 Specific Targets

4.4.2.1 Surface water

The River Suck and its tributaries are significant targets. Water quality in the Suck has been found to be generally good (Class Q4 to Q5). Water is abstracted from the River Suck at Ballinasloe.

An unnamed tributary of the River Suck runs close to the site, immediately to the north. No flow data are recorded for this stream but the Castlerea Landfill occupies around 0.25% of the catchment area of close to 10 km^2. Water quality in this unnamed tributary has not been measured but is likely to be similar to that found upstream of the landfill at CSW3 and to be generally good.

Water Quality Standards are given in the Upper Shannon for 5 determinands, dissolved oxygen, ammonia, BOD, oxidised nitrogen and total phosphorous. These are listed in Table 4.1.

Table 4.1

Water Quality Standards

Determinand	Units	Equal to or greater than 99.9% of time	Equal to or greater than 95% of time	Equal to or greater than 50% of time
Dissolved Oxygen	mg/l	4	6	9
BOD (five day)	mg/l	-	5	3
Ammonia (total)	mg/l	-	0.5	0.2
Oxidised Nitrogen	mg/l	11	5	3
Total phosphorous	mg/l	-	0.15	0.05

4.4.2.2 Groundwater

The Oakport Limestone lies beneath the site at depth and is a regionally important aquifer (Section 3.7). Vertical migration of leachate could have a deleterious impact on this aquifer.

4.4.2.3 Air

The Castlerea Landfill generates and will continue for some years to generate of the order of 800 000 m^3/year (DTI, 1998) of landfill gas. The principal targets of landfill gas will be local buildings where gas can accumulate to potentially explosive concentrations. The nearest building to the site are some kilometres from the site. It is considered unlikely that landfill gas could migrate this distance within the thin unsaturated zone. Migrating landfill gas may also affect vegetation in the vicinity of the site.

4.5 Possible Impacts On Targets

4.5.1 Introduction

This section examines the possible impacts to the targets identified in Section 3.3 from leachate migrating from Castlerea Landfill site. The primary targets have been identified as the nearby tributary of the River Suck and the Oakport Limestone.

River water quality for the Suck has been monitored near the site at Cloondacarra Bridge, and details of this are given in Table 3.3.

4.5.2 Surface Water

If any contaminants within the leachate are diluted to concentrations where they do not affect the quality of the river then there will be no discernible impact on the nearby tributary of the River Suck. This is regardless of the time of travel or attenuation of contaminants from the leachate to the target.

The contribution of the landfill site to the volume of water flowing in the tributary can be assessed by means of relative areas. The landfill site occupies an area of approximately 2.5 ha (0.025 km^2). The tributary has a catchment area of approximately 10 km^2 at the point at which drainage from the landfill enters it. Therefore the landfill site area contributes about 0.25% of the total flow in the stream i.e. the stream provides a dilution factor of 400 to the landfill drainage. This analysis assumes that all areas of the catchment contribute equally to the total drainage.

The quality of water migrating from the landfill site is best represented by the samples from CSW3. Maximum concentrations of the water quality determinands found at CSW3 are given in Table 2.4 and are DO_2 12%, Ammoniacal nitrogen 618 mg/l, Total oxidised nitrogen 0.38 mg/l and BOD 32.5 mg/l. Total phosphorus has not been measured. A dilution of 400 times will reduce concentrations of TON and BOD to within the required water quality standards. Ammonia will be reduced to 1.55 mg/l, still in excess of water quality standards.

Using the same approach for the River Suck the total catchment area (at Willsbrook) is 182 km^2 (including the unnamed tributary stream) of which the unnamed tributary forms 10 km^2. There will therefore be an additional 18 times dilution of the stream water entering the Suck. This will reduce ammonia from the estimated value of 1.55 to 0.086 mg/l, well below water quality guideline values.

4.5.3 Groundwater

Vertically migrating leachate will pass through approximately 12 m of Boulder Clay before reaching the Oakport Limestone. In its passage through the Boulder Clay it will be subject to attenuation processes. Attenuation processes include cation exchange, sorption, oxidation and biodegradation and the potential for these to reduce contaminant concentrations at Castlerea are assessed below.

4.5.3.1 Cation exchange

Cation exchange is the process whereby contaminants such as ammonia and metals become attached to clay minerals present within the strata through which the leachate passes. At Castlerea the cation exchange capacity (CEC) of the Boulder Clay will be considerable, although peat also has significant CEC.

The CEC for the Boulder Clay is likely to be between 100 and 200 meq/kg (DOE (UK), 1996). The CEC of local peat has been measured at Ballaghaderreen Landfill (Co Roscommon) as 948 mg/l. Contaminants such as ammonia and a number of metals in leachate leaking down through the Boulder Clay would be attenuated. To illustrate this, the time to exhaust the CEC has been calculated in Table 4.1.

This shows that on the basis of the range of ammonia concentrations measured in the leachate it would take in excess of 17 000 years to exhaust the available CEC. Given that the waste will fully degrade within this time, it is extremely unlikely that the available CEC will be used up. Consequently contaminants are unlikely to break through into the underlying Oakport Limestone.

The times to exhaust the CEC derived in Table 4.2 are large due to the 12 m thickness of Boulder Clay.

The considerable CEC of peat has not been invoked in this analysis as all parts of the landfill sit directly over Boulder Clay.

Table 4.2

Calculation of Time to Exhaust CEC of Boulder Clay

Parameter		Values			Reference
		Min	Mean	Max	
Calculating Available CEC					
Thickness (m)	b		12		
Area (ha)	A		2.5		
Volume (m^3) $\times 10^3$	V		300		(V = b.A)
Bulk Density (kg/m^3)	r	1620	1620	1620	2.7 g/cm^3 rock density of 40% total porosity
Reaction Efficiency	e		0.35		LandSim* default
CEC (meq/kg)	CEC	100	150	200	LandSim manual Table 5.6
Available CECx10^9 (meq)		**17.0**	**25.5**	**34.0**	(=V.r.CEC.e)
Calculating Loading Rate					
Flow through base (m^3/yr)	Q	750	2500	7500	Max estimated rate (see Section 2.7.2)
Ammonia Conc (mg/l N)	C	48	681	1836	Table 2.4
Conversion factor	x	1/14	1/14	1/14	valency/mol wt
Loading Rate (meq/yr) $\times 10^3$	**LR**	**2.5**	**121**	**983**	(LR = Q.C.x)
Time to exhaust CEC (000 yrs)	t	17	210	14 000	($t=CEC_{avail}/LR$)

Note:
* Reference DOE (UK), 1996

4.5.3.2 Sorption of organic contaminants

Sorption is the process by which dissolved species partition between solid and liquid phases. For organic contaminants sorption is dominantly to the organic proportion of

the solid phase. The organic content of peat is extremely high and is therefore likely to remove much of the organic content by sorption, thus preventing its transport into underlying Boulder Clay.

4.5.3.3 Other processes

Other processes which will reduce or remove the impact of contaminants within the leachate on targets is degradation of organic contaminants. These will include volatilisation where an unsaturated zone is present, and biodegradation.

It should be noted that a few constituents, in particular chloride, will not be attenuated and so increased concentrations could eventually be experienced in the Oakport Limestone. The volume of leachate penetrating to the Oakport Limestone is estimated as 3 to 30 mm/yr over an area of 2.5 ha, giving a total volume 75 to 750 m^3/yr. Dilution within the Oakport Limestone is likely to be significant and the impact of this volume of leachate is anticipated to be small to negligible.

4.5.4 Landfill Gas

The site will continue to generate landfill gas for many years. In the UK, the Department Trade and Industry published guidelines suggest that landfill gas generation rates are 13 m^3/yr per tonne at peak, falling by 50% over 10 years and by 75% over 20 years. Therefore waste deposited in 1997 will be generating 3.25 m^3/yr per tonne in 2017. Landfill gas generation is likely to continue for up to 50 years post closure. The duration of landfill gas generation will be dependant upon the rate of waste degradation at the site which in turn will depend upon the relative moisture content. Present rate of production is probably close to 800 000 m^3/year.

No potential targets, with the exception of on-site vegetation is likely to be affected as the site is relatively remote and is a landraise.

4.5.5 Visual Impact and Litter

The site is a small landraise now 3 to 4 m above the surrounding pasture, as such it will always intrude slightly into the profile of the valley. This intrusion will be particularly marked if the potential for generation of wind blown litter is not prevented by complete covering of top and sides by 0.5 m of the clay cover.

5. RECOMMENDATIONS FOR FUTURE MANAGEMENT OF CASTLEREA LANDFILL SITE

5.1 Introduction

Castlerea Landfill Site has been closed and Roscommon County Council wish to restore the site such that it requires minimal future maintenance whilst reducing the risk to the environment. In this section the options for minimising risk at least cost are considered.

5.2 Present Situation

At the present time the site is closed and in the process of being capped with imported Boulder Clay. There are no leachate or gas control measures in place at the site.

5.3 Future Management Options

5.3.1 Surface Water

Leachate from Castlerea Landfill site has been shown to have a potentially deleterious impact on water quality in the unnamed stream to the north. Future management of the site will require that this situation continues to be monitored and may require some control of leachate. Options for leachate control are considered below.

Construction of a low permeability cap will reduce leachate generation by reducing infiltration. A fully engineered cap of say 1 m of clay with a hydraulic conductivity of 1×10^{-9} m/s will reduce infiltration to approximately 30 mm/yr, approximately 5% of the effective rainfall of 681 mm/yr. This would give a dilution factor of 8000 times in the nearby unnamed stream, sufficient to reduce ammonia concentrations from 618 mg/l to 0.077 mg/l, well below the target water quality standards. This cap would be required to be keyed into the existing Boulder Clay beneath the site to contain the leachate.

A less rigorously constructed cap of say around 0.5 m of clay with a hydraulic conductivity of 1×10^{-8} m/s would permit maximum infiltration of about 315 mm/yr giving a dilution factor of 860 times over effective rainfall. This will be reduce ammonia concentrations in the unnamed ditch from 618 mg/l to 0.72 mg/l still above the water quality standard but close to the 95% of the time value. It is likely that ammonia concentrations will reduce over time and the present concentrations are close

to maximum. It is therefore likely that in future ammonia will fall to concentrations that allow dilution to give concentrations in the unnamed stream close to acceptable water quality standards.

If required a possible, simple method of leachate treatment to reduce ammonia would be to utilise the CEC of peat. Leachate could be directed through a known thickness of peat before entering the drainage ditches around the site. The CEC of local peat has been measured at Ballaghadreen as 948 meq/l (Entec, 1998, Report No 19428N085il). Table 5.1 examines the capacity of peat to remove ammonia by cation exchange.

Table 5.1

Ammonia Removal by Peat Using Cation Exchange

Ammoniacal N Concentration	Ammoniacal N Concentration	CEC Capacity of Peat per m^3	Volume of Water Treated by 1 m^3 of peat
mg/l	meq/ m^3	meq	m^3
100	7000	948000	133
600	43000	948000	22
1000	71000	948000	13
2000	142000	948000	6

Infiltration at the site, were it uncapped, would be approximately equal to the effective rainfall over the site area of 2.5 ha giving a leachate volume of 17 000 m^3/annum. A fully engineered cap would reduce this to 850 m^3/annum. From Table 5.1 it can be seen that 772 m^3 of peat is required to remove approximately one years ammonia output for the uncapped site (leachate with a concentration of ammonia of 600 mg/l). Whereas only 35 m^3 of peat would be required for the leachate from an site with a fully engineered cap. For the likely covering of compacted Boulder Clay 300/400 m^3 of peat would be required.

Increasing the time for flow to the target and oxygenating of leachate by use of small weirs would also provide some reduction of ammonia concentrations. This could be achieved by directing leachate drainage to the drains on the eastern and western boundaries of the site and modifying the channels to provide shallow storage over much of their length and a small concrete weir with steps on the downstream side at the

northern end. This will permit some oxidation and aeration and could be linked with provision of reeds beds and willow copicing around the site margins. In view of the relatively low level of risk and the nature of the site this may provide the most appropriate means of environmental risk reduction.

5.3.2 Groundwater

The risk to groundwater has been demonstrated to be low and no further actions are likely to be required.

5.3.3 Landfill Gas

The site provides landfill gas but measures to control generation of gas are likely to prove unnecessary due to the remoteness of the site. However, measures to aid the venting of landfill gas will prevent vegetation die back on the landfill cover and control the direction of landfill gas releases. It would therefore be appropriate to install gas vent pipes through the waste at 30 to 40 m intervals.

5.3.4 Visual appearance

The landfill is situated in a low lying area and forms a prominent feature as it raised up to 3 m above the surrounding land. The impact of this can be significantly reduced by promoting vegetation growth over the landfill cap. This will require that an appropriate subsoil and topsoil is placed over the cap. Planting of trees could be used to effectively shield the site from view. Promotion of reed beds and will as part of this screening exercise will promote leachate control.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Castlerea Landfill Site has recently been closed. Leachate generation at the site is likely to lead to small scale local derogation of water quality in a nearby stream unless mitigation measures are undertaken.

The most effective leachate control measure will be to reduce infiltration to the waste and thereby reduce the quantity of leachate generated. This effect can be maximised by construction of low permeability cap over the landfill waste. The present programme of capping is likely to reduce infiltration to around 200 m/year. Further improvement of leachate quality can be achieved by providing limited storage in the lateral drainage and small stepped weirs at their outfalls.

Promotion of vegetation growth will be assisted by provision of 10 to 15 gas venting holes through the waste pile.

There is no indication of placing waste material other than normal domestic, commercial and water sewage treatment waste at Castlerea. Monitoring should however, continue, in accordance with EPA Monitoring guidelines (EPA, 1996), at the established leachate, groundwater and surface water monitoring network. For aftercare the suggested initial sampling frequency for monitoring is six monthly (EPA, 1996, Appendix A, Table A1).

6.2 Recommendations

The following works should be undertaken at the Castlerea Site:

- Cover top and sides of waste pile with minimum 0.5 m thickness of Boulder Clay, placed to maximise surface runoff from the cover.
- Construct some concrete weirs with 2 or 3 small steps at outfalls of site perimeter drainage ditches.
- Promote reed and willow growth around the site margins.
- Construct 10 to 15 gas vent holes in the waste pile.

- Continue surface, groundwater and leachate monitoring at 6 monthly intervals for 1 year and annually thereafter for 4 or 5 years pending a final review of the situation.

7. REFERENCES

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PLATES

Plate 3.1: Castlerea Landfill
Ponded leachate at foot
of waste area

Plate 3.2: Leachate
discharge at site boundary

APPENDIX A

WASTE DELIVERY DATA (1997/98)

(29 Pages)

19428 0.121

ENTER

Use of Council Tipsites for disposal of Refuse

July, 1998 Name of Tipsite Castlereagh

DATE	NUMBER OF USERS PER DAY							
	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
01/07/98		3						
02/07/98		2						
03/07/98		3						
04/07/98		1	2	6				
06/07/98		2	1					
07/07/98		1					1	
08/07/98		2						
09/07/98		1		1				
10/07/98		3	1					
11/07/98		4	2	8				
13/07/98		4	1	2				
14/07/98		2	1	1	1		1	
15/07/98		3	1	1				
16/07/98		1	1					
17/07/98		2	1	1				
18/07/98		2	1	8				
20/07/98		1	1					
21/07/98		3	1	1			1	
22/07/98		1	1	1				
23/07/98		2	1	1				
24/07/98		2	1	1				
25/07/98		2	1	8				
27/07/98		1	1/8	1				
28/07/98		2	1	1	1		1	
29/07/98		4	1	1	1	1	1	
30/07/98		4	1	1	1	1	1	
31/07/98		9	1	1	1	1	1	

Use of Council Tipsites for disposal of Refuse

June, 1998 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY								
DATE	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
01/06/98	—	—	—	—	—	—	—	—
02/06/98	—	5	—	6	—	—	1	—
03/06/98	—	1	2	—	—	—	—	—
04/06/98	—	—	—	—	—	—	—	—
05/06/98	—	1	—	—	—	—	—	—
06/06/98	—	2	—	14	—	—	—	—
08/06/98	—	2	—	—	—	—	—	—
09/06/98	—	3	—	—	—	—	1	—
10/06/98	—	1	—	—	—	—	—	—
11/06/98	—	1	—	—	—	—	—	—
12/06/98	—	2	—	—	—	—	—	—
13/06/98	—	3	2	8	—	—	—	—
15/06/98	—	2	—	—	—	—	—	—
16/06/98	—	2	—	—	—	—	—	—
17/06/98	—	—	—	—	—	—	1	—
18/06/98	—	1	—	—	—	—	—	—
19/06/98	—	2	—	1	—	—	—	—
20/06/98	—	3	—	8	—	—	—	—
22/06/98	—	1	—	2	—	—	—	—
23/06/98	—	7	—	—	—	—	1	—
24/06/98	—	6	—	—	—	—	—	—
25/06/98	—	6	—	1	—	—	—	—
26/06/98	—	2	—	—	—	—	—	—
27/06/98	—	2	—	4	—	—	—	—
29/06/98	—	2	—	—	—	—	—	—
30/06/98	—	2	—	—	—	—	1	—
Totals		55	(4)	(144)			(2)	

Use of Council Tipsites for disposal of Refuse

May, 1998 Name of Tipsite Castlerea

DATE	NUMBER OF USERS PER DAY							
	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
01/05/98	—	2	—	—	—	—	—	—
02/05/98	—	1	1	—	—	—	—	—
04/05/98	—	—	—	—	—	—	—	—
05/05/98	—	1	—	—	—	—	—	—
06/05/98	—	1	2	—	—	—	1	—
07/05/98	—	1	—	—	—	—	—	—
08/05/98	—	2	—	1	—	—	—	—
09/05/98	—	4	—	—	—	—	—	—
11/05/98	—	2	1	—	—	—	—	—
12/05/98	—	1	1	—	—	—	—	—
13/05/98	—	1	—	—	—	—	1	—
14/05/98	—	2	1	—	—	—	—	—
15/05/98	—	4	1	—	—	—	—	—
16/05/98	—	1	1	—	—	—	—	—
18/05/98	—	1	3	—	—	—	—	—
19/05/98	—	3	—	1	—	—	1	—
20/05/98	—	3	—	—	—	—	—	—
21/05/98	—	1	—	—	—	—	—	—
22/05/98	—	2	1	—	—	—	—	—
23/05/98	—	2	1	—	—	—	—	—
25/05/98	—	1	1	4	—	—	—	—
26/05/98	—	2	—	—	—	—	1	—
27/05/98	—	1	1	2	—	—	—	—
28/05/98	—	—	—	1	—	—	—	—
29/05/98	—	—	1	1	—	—	—	—
30/05/98	—	6	2	—	—	—	—	—
	0.45	18	10					

Use of Council Tipsites for disposal of Refuse
April 1998 Name of Tipsite Castlerea

DATE	NUMBER OF USERS PER DAY							
	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
01/04/98	—	1	2	1	—	—	—	—
02/04/98	—	1	—	—	—	—	—	—
03/04/98	—	3	1	—	—	—	—	—
04/04/98	—	1	1	1	—	—	—	—
06/04/98	—	1	—	—	—	—	—	—
07/04/98	—	2	2	—	—	—	1	—
08/04/98	—	5	—	—	—	—	—	—
09/04/98	—	6	1	—	—	—	—	—
10/04/98	—	—	—	—	—	—	—	—
11/04/98	—	—	—	—	—	—	—	—
13/04/98	—	—	—	—	—	—	—	—
14/04/98	—	4	1	—	—	—	1	—
15/04/98	—	5	3	—	—	—	—	—
16/04/98	—	2	—	—	—	—	—	—
17/04/98	—	3	—	—	1	—	—	—
18/04/98	—	6	—	—	—	—	—	—
20/04/98	—	2	1	—	—	—	—	—
21/04/98	—	1	1	—	—	—	1	—
22/04/98	—	—	2	—	—	—	—	—
23/04/98	—	1	—	—	—	—	—	—
24/04/98	—	6	—	—	—	—	—	—
25/04/98	—	6	—	—	—	—	—	—
27/04/98	—	2	—	—	—	—	—	—
28/04/98	—	3	—	—	—	—	1	—
29/04/98	—	2	2	—	—	—	—	—
30/04/98	—	5	—	—	—	—	—	—
		71	17	2	1	—	4	—

Use of Council Tipsites for disposal of Refuse
March 1998
Name of Tipsite CASTLEREA

NUMBER OF USERS PER DAY

DATE	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
02/03/98	—	—	1	—	—	—	—	—
03/03/98	—	—	—	—	—	—	1	—
04/03/98	—	—	—	—	—	—	—	—
05/03/98	—	3	—	—	—	—	—	—
06/03/98	—	2	1	—	—	—	—	—
07/03/98	—	—	—	—	—	—	—	—
09/03/98	—	—	2	—	—	—	—	—
10/03/98	—	—	—	—	—	—	1	—
11/03/98	—	1	—	—	—	—	—	—
12/03/98	—	—	—	—	—	—	—	—
13/03/98	—	1	—	—	—	—	—	—
14/03/98	—	2	—	—	—	—	—	—
16/03/98	—	2	—	—	—	—	—	—
17/03/98	—	—	—	—	—	—	1	—
18/03/98	—	2	—	—	—	—	—	—
19/03/98	—	—	1	—	—	—	—	—
20/03/98	—	2	1	—	—	—	—	—
21/03/98	—	—	—	—	—	—	—	—
23/03/98	—	—	1	—	—	—	—	—
24/03/98	—	—	—	—	—	—	1	—
25/03/98	—	—	1	1	—	—	—	—
26/03/98	—	2	—	—	—	—	—	—
27/03/98	—	1	—	—	—	—	—	—
28/03/98	—	—	—	—	—	—	—	—
30/03/98	—	1	—	—	—	—	—	—
31/03/98	—	2	1	—	—	—	1	—
	—	21 Ltr	9 Ltr	2 Ltr	— Ltr	—	5	—

Use of Council Tipsites for disposal of Refuse

February, 1998 Name of Tipsite CASTLEREA

NUMBER OF USERS PER DAY

DATE	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
02/02/98	—	—	—	—	—	—	—	—
03/02/98	—	—	—	—	—	—	—	—
04/02/98	—	—	—	—	—	—	—	—
05/02/98	—	£5	—	—	—	—	—	—
06/02/98	—	—	—	—	—	—	—	—
07/02/98	—	£5	—	—	—	—	—	—
09/02/98	—	—	—	—	—	—	—	—
10/02/98	—	5	—	—	—	—	£1	—
11/02/98	—	1	1	—	—	—	—	—
12/02/98	—	—	3	—	—	—	—	—
13/02/98	—	2	1	—	—	—	—	—
14/02/98	—	2	1	—	—	—	—	—
16/02/98	—	1	1	—	—	—	—	—
17/02/98	—	4	1	—	—	—	1	—
18/02/98	—	1	1	2	—	—	—	—
19/02/98	—	2	—	—	—	—	—	—
20/02/98	—	2	1	1	—	—	—	—
21/02/98	—	3	2	—	—	—	—	—
23/02/98	—	1	1	—	—	—	—	—
24/02/98	—	—	1	—	—	—	1	—
25/02/98	—	1	—	1	—	—	—	—
26/02/98	—	1	1	—	—	—	—	—
27/02/98	—	—	—	—	—	—	—	—
28/02/98	1	1	—	—	—	—	—	—
	—	7	15	4	—	—	3	—

£5 (1) £12 (2) £16 (2) £35 (2) (+5) £36 (3)

Use of Council Tipsites for disposal of Refuse

January, 1998 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY

DATE	2.00	8.00	15.00	40.00	60.00	120.00	160.00	180.00
02/01/98								
03/01/98								
05/01/98								
06/01/98								
07/01/98		1	3					
08/01/98								
09/01/98		1	1					
10/01/98		1	1					
12/01/98		2						
13/01/98			2					
14/01/98								
15/01/98		1						
16/01/98		1						
17/01/98		1						
19/01/98			1					
20/01/98			2					
21/01/98			3					
22/01/98		3						
23/01/98								
24/01/98		1						
26/01/98		1						
27/01/98								
28/01/98		2	1					
29/01/98		3						
30/01/98		1	1					
31/01/98		1	2					
		20	18					

CASTLEREA LANDFILL SITE 1997

	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
January					
February					
March					
April					
May	653	222	165	83	0
June	351	133	100	66	0
July	425	117	70	40	7
August	542	139	92	60	5
September	509	82	63	3	4
October	600	80	92	39	5
November	542	77	59	43	22
December	500	73	69	40	9

BALLAGHADERREEN LANDFILL SITE

	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
January	754	91	72	64	116
February	668	68	57	37	36
March	598	65	59	50	35
April	679	80	65	61	42
May	677	78	76	53	110
June	694	78	65	64	56
July	858	97	79	74	65
August					
September	842	107	94	81	77
October					
November					
December					

Use of Council Tipsites for disposal of domestic refuse by private individuals
December 1997 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/12/97	14	2	3	1	
02/12/97	18	3	2	0	
03/12/97	12	0	1	2	
04/12/97	17	4	2	1	1
05/12/97	19	2	0	1	
06/12/97	28	6	4	3	
08/12/97	7	0	1	0	
09/12/97	16	1	2	0	
10/12/97	19	4	1	2	
11/12/97	17	1	2	1	
12/12/97	19	2	0	1	
13/12/97	29	7	5	4	6
15/12/97	11	2	2	1	
16/12/97	19	3	4	2	1
17/12/97	22	1	2	1	
18/12/97	20	2	1	2	
19/12/97	21	1	0	1	1
20/12/97	38	4	6	3	
22/12/97	17	2	3	1	
23/12/97	29	1	4	0	
24/12/97					
25/12/97					
26/12/97					
27/12/97					
29/12/97	40	10	8	4	
30/12/97	48	9	11	6	
31/12/97	20	6	7	3	
	500	73	69	40	9

Use of Council Tipsites for disposal of domestic refuse by private individuals
November 1997 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/11/97	30	5	3	2	
02/11/97	12	2	1	0	
03/11/97	18	1	0	1	
04/11/97	17	2	4	2	5
05/11/97	11	3	3	0	10
06/11/97	19	2	1	1	
07/11/97	12	4	2	0	1
08/11/97	31	7	4	3	
10/11/97	20	3	0	1	
11/11/97	19	2	2	3	
12/11/97	17	1	4	1	
13/11/97	23	2	1	2	1
14/11/97	20	3	2	1	
15/11/97	24	6	4	3	
17/11/97	12	1	0	0	
18/11/97	14	2	3	1	
19/11/97	20	1	1	0	
20/11/97	28	4	2	1	
21/11/97	19	2	3	2	
22/11/97	42	6	7	4	
24/11/97	16	3	0	2	
25/11/97	19	1	2	3	
26/11/97	22	4	3	1	
27/11/97	26	3	2	2	
28/11/97	19	2	1	3	
29/11/97	32	5	4	4	
	542	77	59	43	22

Use of Council Tipsites for disposal of domestic refuse by private individuals

October 1997 Name of Tipsite: Carstheen

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/10/97	18	2	4	2	
02/10/97	28	9	12	0	
03/10/97	17	2	4	1	
04/10/97	24	1	5	2	1
06/10/97	20	3	2	1	
07/10/97	17	0	4	6	0
08/10/97	22	1	3	0	1
09/10/97	18	3	2	1	
10/10/97	24	1	0	0	
11/10/97	34	8	5	3	1
13/10/97	19	2	1	0	
14/10/97	12	0	3	1	
15/10/97	20	3	2	3	
16/10/97	24	4	1	0	
17/10/97	18	2	3	2	
18/10/97	30	6	8	3	
/10/97	20	0	4	0	
21/10/97	19	2	3	1	
22/10/97	24	4	1	2	1
23/10/97	19	2	3	1	
24/10/97	14	0	4	0	
25/10/97	32	6	6	2	
27/10/97	11	2	0	1	
28/10/97	35	8	6	4	
29/10/97	28	2	3	2	
30/10/97	18	3	2	0	
31/10/97	30	4	2	1	1
	600	80	92	39	5

Use of Council Tipsites for disposal of domestic refuse by private individuals
September 1997 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/09/97	11	0	2		
02/09/97	14	2	1		
03/09/97	16	1	0		
04/09/97	20	5	2	2	
05/09/97	19	2	1	1	
06/09/97	22	3	4	0	
08/09/97	17	7	2		
09/09/97	21	4	0		
10/09/97	18	2	1		
11/09/97	28	1	3		
12/09/97	19	4	1		
13/09/97	20	2	0		1
15/09/97	17	0	2		
16/09/97	16	1	1		
17/09/97	19	5	3		
18/09/97	17	4	2		
19/09/97	12	0	1		
20/09/97	32	7	10		
22/09/97	17	2	1		
23/09/97	20	3	2		
24/09/97	21	1	0		1
25/09/97	19	4	8		
26/09/97	20	4	3		
27/09/97	35	6	5		1
29/09/97	22	7	14		1
30/09/97	17	5	14		
	509	82	63	3	4

Use of Council Tipsites for disposal of domestic refuse by private individuals
August, 1997 Name of Tipsite Castlerea

DATE	NUMBER OF USERS PER DAY				
	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/08/97	20	5	6	4	
02/08/97	30	11	3	6	
04/08/97	15	3	2	1	
05/08/97	16	2	1	0	
06/08/97	17	4	3	1	1
07/08/97	22	3	4	2	
08/08/97	19	7	9	4	
09/08/97	17	2	4	0	
11/08/97	38	12	9	3	
12/08/97	21	4	6	0	
13/08/97	14	6	2	2	
14/08/97	18	7	1	3	
15/08/97	19	3	2	1	
16/08/97	30	8	5	8	
18/08/97	16	2	4	0	
19/08/97	20	4	1	2	
20/08/97	19	6	2	1	
21/08/97	20	7	4	3	1
22/08/97	28	6	3	2	1
23/08/97	20	8	3	0	
25/08/97	25	4	2	6	
26/08/97	19	6	5	2	1
27/08/97	22	4	3	2	
28/08/97	26	8	5	4	1
29/08/97	20	14	3	2	
30/08/97	12	3	0	1	
	542	139	92	60	5

Use of Council Tipsites for disposal of domestic refuse by private individuals
July 1997

Name of Tipsite Castlerea

NUMBER OF USERS PER DAY

DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/07/97	9	2	1	0	
02/07/97	4	1	0	1	
03/07/97	6	4	3	3	
04/07/97	11	3	1	3	
05/07/97	23	18	5	4	
07/07/97	18	9	1	0	
08/07/97	12	2	0	3	
09/07/97	20	7	4	1	
10/07/97	14	3	1	1	
11/07/97	26	5	3	2	
12/07/97	24	9	6	0	0
14/07/97	6	2	0	0	1
15/07/97	19	3	4	2	
16/07/97	17	2	1	0	
17/07/97	26	5	4	0	
18/07/97	18	2	1	4	1
19/07/97	28	5	8	3	
21/07/97	9	3	2	0	
22/07/97	6	4	3	2	
23/07/97	8	3	2	1	
24/07/97	10	2	4	3	
25/07/97	8	3	2	0	1
26/07/97	30	9	6	4	
28/07/97	26	3	2	0	
29/07/97	19	2	4	0	1
30/07/97	16	4	2	3	3
31/07/97	12	2	0	0	
	425	117	70	40	7

Use of Council Tipsites for disposal of domestic refuse by private individuals

June, 1997 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
02/06/97					
03/06/97	10	4	0	2	
04/06/97	18	6	3	1	
05/06/97	15	3	4	0	
06/06/97	12	2	4	2	
07/06/97	25	9	10	7	
09/06/97	12	7	2	1	
10/06/97	8	2	4	5	
11/06/97	16	6	5	0	
12/06/97	19	12	8	2	
13/06/97	23	3	2	4	
14/06/97	31	12	9	8	
16/06/97	9	6	3	2	
17/06/97	19	3	2	5	
18/06/97	10	5	3	7	
19/06/97	8	4	2	4	
20/06/97		6	3	2	
21/06/97	11	8	6	0	
23/06/97	7	2	7	3	
24/06/97	3	3	8	1	
25/06/97	19	2	6	1	
26/06/97	17	0	2	2	
27/06/97	10	4	1	0	
28/06/97	29	10	4	5	
30/06/97	20	8	3	2	

Use of Council Tipsites for disposal of domestic refuse by private individuals

May, 1997 Name of Tipsite Cashelea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/05/97	19	2	14	2	
02/05/97	23	7	9	1	
03/05/97	20	4	2	6	
05/05/97	27	3	5	3	
06/05/97	17	8	10	4	
07/05/97	22	11	2	0	
08/05/97	32	3	7	7	
09/05/97	17	9	5	0	
10/05/97	26	5	2	1	
12/05/97	29	3	14	7	
13/05/97	22	3	3	4	
14/05/97	28	6	8	0	
15/05/97	19	7	14	3	
16/05/97	27		2	9	
17/05/97	42	8	5	2	
19/05/97	28	25	7	4	
20/05/97	18	11	4	6	
21/05/97	20	9	9	4	
22/05/97	26	13	8	7	
23/05/97	17	20	10	14	
24/05/97	37	29	15	2	
26/05/97	19	3	2	0	
27/05/97	21	5	7	1	
28/05/97	18	7	6	3	
29/05/97	14	8	2	0	
30/05/97	23	4	5	1	
31/05/97	20	0	9	2	

Use of Council Tipsites for disposal of domestic refuse by private individuals
December 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
02/12/96	32	2	3	—	1
03/12/96	28	3	3	—	—
04/12/96	26	4	4	—	—
05/12/96	23	3	2	—	—
06/12/96	32	5	2	—	—
07/12/96	35	4	—	—	—
09/12/96	26	3	1	2	2
10/12/96	24	2	4	—	—
11/12/96	27	4	—	—	—
12/11/96	22	3	—	1	—
13/12/96	29	2	—	—	—
14/12/96	36	4	—	—	—
16/12/96	39	3	2	—	—
17/12/96	28	2	—	—	—
18/12/96	24	3	—	—	—
19/12/96	32	2	—	—	2
20/12/96	34	2	3	—	—
21/12/96	36	4	2	—	—
23/12/96	32	6	—	1	—
24/12/96	[redacted]	X	X	—	—
27/12/96	[redacted]	X	X	—	—
28/12/96	65 [redacted]	25	11	2	—
30/12/96	52 [redacted]	30	15	—	—
31/12/96	76	14	19	—	—
				—	
				—	
				—	

Use of Council Tipsites for disposal of domestic refuse by private individuals
November 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/11/96	34	3	3	~	1
02/11/96	30	4	4	~	~
04/11/96	27	3	3	~	~
05/11/96	35	2	2	1	~
06/11/96	26	2	5	~	~
07/11/96	18	4	4	~	2
08/11/96	29	3	2	~	~
09/11/96	27	3	2	~	~
11/11/96	34	2	1	2	~
12/11/96	29	5	~	~	~
13/11/96	27	3	~	~	~
14/11/96	36	4	~	~	~
15/11/96	30	3	3	~	1
16/11/96	22	3	3	~	~
18/11/96	32	4	~	1	~
19/11/96	25	2	2	~	2
20/11/96	23	2	2	~	~
21/11/96	21	5	~	~	~
22/11/96	30	5	~	~	~
23/11/96	32	5	1	~	1
25/11/96	19	3	4	2	~
26/11/96	28	2	4	~	1
27/11/96	34	3	3	~	1
28/11/96	22	3	1	~	~
29/11/96	20	4	1	~	~
30/11/96	37	2	2	2	~
	40	1	5	~	~

Use of Council Tipsites for disposal of domestic refuse by private individuals
October 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/10/96	22	3	2	—	2
02/10/96	26	3	1	—	—
03/10/96	19	2	3	—	—
04/10/96	28	4	2	—	—
05/10/96	36	5	4	—	—
07/10/96	30	2	5	1	—
08/10/96	29	4	1	—	2
09/10/96	20	2	—	—	—
10/10/96	27	2	2	—	—
11/10/96	21	4	4	1	—
12/10/96	34	2	3	—	—
14/10/96	30	6	4	—	1
15/10/96	28	3	3	—	—
16/10/96	39	2	—	—	—
17/10/96	32	2	4	—	—
18/10/96	36	—	—	2	—
19/10/96	23	—	3	—	1
21/10/96	29	2	2	—	—
22/10/96	24	3	1	2	—
23/10/96	26	4	5	—	—
24/10/96	26	2	—	—	—
25/10/96	29	4	4	1	1
26/10/96	24	5	1	—	—
28/10/96	27	4	2	—	—
29/10/96	26	5	—	—	2
30/10/96	24	2	—	2	—
31/10/96	20	4	2	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
September 1996 Name of Tipsite Castlerea

DATE	NUMBER OF USERS PER DAY				
	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
2/09/96	22	4	3	2	1
3/09/96	26	2	2	—	1
4/09/96	32	2	3	—	—
5/09/96	28	—	2	—	—
6/09/96	25	4	1	—	—
7/09/96	20	3	4	2	—
9/09/96	19	3	2	—	—
0/ /96	26	6	2	1	—
1/09/96	33	4	4	—	—
2/09/96	26	3	2	—	1
3/09/96	22	5	3	—	—
4/09/96	18	5	3	—	—
6/09/96	29	4	4	—	—
7/09/96	24	—	3	—	1
8/09/96	27	2	2	—	—
9/09/96	29	6	5	2	—
0/09/96	27	—	3	—	—
1/09/96	29	5	2	2	1
3/09/96	32	3	4	—	—
4/09/96	24	5	3	—	—
5/09/96	27	2	—	1	—
6/09/96	20	1	2	—	—
7/09/96	22	2	3	—	—
8/09/96	26	2	4	—	1
0/09/96	30	6	2	—	—
	32	2	2	2	—
	35	4	1	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
August 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/08/96	22	2	2	1	—
02/08/96	26	4	1	—	—
03/08/96	30	2	2	—	1
05/08/96	24	1	—	—	—
06/08/96	20	3	2	—	—
07/08/96	24	4	—	2	2
08/08/96	32	3	4	—	—
09/08/96	26	2	2	—	—
10/08/96	28	1	3	—	—
12/08/96	32	4	4	—	—
13/08/96	29	6	—	2	2
14/08/96	25	2	2	—	—
15/08/96	22	—	2	—	—
16/08/96	30	2	1	1	—
17/08/96	19	5	3	1	—
19/08/96	24	3	—	—	—
20/08/96	22	6	5	—	2
21/08/96	23	5	3	2	—
22/08/96	26	2	2	—	—
23/08/96	24	1	2	—	—
24/08/96	31	6	2	1	—
26/08/96	34	3	6	—	—
27/08/96	18	3	7	—	—
28/08/96	28	—	3	—	—
29/08/96	22	2	2	—	—
30/08/96	35	4	4	—	—
31/08/96	35	—	1	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals

July 1996 Name of Tipsite Castlerea

DATE	NUMBER OF USERS PER DAY				
	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/07/96	28	3	2	—	—
02/07/96	23	3	4	—	—
03/07/96	30	2	3	—	—
04/07/96	25	1	4	—	—
05/07/96	20	1	2	1	1
06/07/96	29	1	1	—	—
08/07/96	27	4	—	—	—
09/07/96	20	0	2	—	—
10/07/96	22	0	4	—	—
11/07/96	18	2	3	—	—
12/07/96	29	3	—	—	2
13/07/96	25	—	—	1	—
15/07/96	32	4	2	—	—
16/07/96	29	3	1	—	—
17/07/96	20	2	2	—	—
18/07/96	19	1	3	2	1
19/07/96	24	6	2	—	—
20/07/96	27	2	1	—	—
22/07/96	31	—	2	—	—
23/07/96	18	—	4	—	1
24/07/96	22	3	6	—	—
25/07/96	21	2	2	—	1
26/07/96	27	1	—	2	1
27/07/96	22	2	2	—	—
29/07/96	21	—	—	—	—
30/07/96	X29	—	—	—	—
31/07/96	18	2	3	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
June, 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/06/96	24	3	2	—	1
03/06/96	21	2	2	—	—
04/06/96	23	1	3	1	—
05/06/96	22	2	1	2	—
06/06/96	27	—	2	—	—
07/06/96	26	2	4	—	—
08/06/96	30	4	1	—	—
10/06/96	22	1	1	1	—
11/06/96	26	1	2	—	2
12/06/96	25	—	3	—	—
13/06/96	12	4	2	—	—
14/06/96	22	5	1	1	—
15/06/96	20	4	—	—	—
17/06/96	27	—	4	—	—
18/06/96	17	6	4	2	1
19/06/96	21	2	2	—	—
20/06/96	23	3	3	—	—
21/06/96	24	2	2	—	—
22/06/96	23	4	3	—	—
24/06/96	20	—	5	2	1
25/06/96	26	2	6	—	—
26/06/96	22	6	2	—	—
27/06/96	25	1	—	1	2
28/06/96	26	1	—	1	—
29/06/96	28	3	2	—	—
	19	4	3	—	—
	23	7	4	—	—

D O'Dwyer

Use of Council Tipsites for disposal of domestic refuse by private individuals
May, 1996 Name of Tipsite Castlerea

	NUMBER OF USERS PER DAY				
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/05/96	28	4	3	—	—
02/05/96	19	2	1	2	1
03/05/96	26	1	1	—	1
04/05/96	22	2	2	—	—
06/05/96	18	3	3	—	—
07/05/96	16	6	1	—	—
08/05/96	19	4	2	—	—
09/05/96	25	2	1	1	2
10/05/96	21	1	1	—	1
11/05/96	23	3	1	2	—
13/05/96	29	3	2	—	2
14/05/96	25	4	—	—	—
15/05/96	28	3	2	—	—
16/05/96	27	2	1	1	1
17/05/96	25	2	3	1	—
18/05/96	19	3	1	3	1
20/05/96	20	4	4	—	2
21/05/96	22	1	2	2	—
22/05/96	27	2	1	—	—
23/05/96	21	2	3	2	—
24/05/96	24	1	4	—	1
25/05/96	25	1	2	2	—
27/05/96	28	3	1	—	1
28/05/96	26	4	2	1	1
29/05/96	21	2	1	2	—
30/05/96	25	1	4	1	2
31/05/96	24	5	5	2	—

Use of Council Tipsites for disposal of domestic refuse by private individuals

April, 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/04/96	22	4	2	—	—
02/04/96	18	2	3	1	1
03/04/96	26	3	1	2	—
04/04/96	20	5	4	3	—
05/04/96	21	2	1	2	—
06/04/96	25	3	3	2	—
08/04/96	23	2	4	1	—
09/04/96	17	1	2	—	1
10/04/96	26	0	1	2	—
11/04/96	22	4	—	4	—
12/04/96	19	3	2	—	—
13/04/96	26	5	3	—	2
15/04/96	28	1	—	2	—
16/04/96	22	3	4	1	—
17/04/96	20	4	6	3	—
18/04/96	19	5	2	0	—
19/04/96	22	2	4	1	—
20/04/96	24	1	2	—	—
22/04/96	21	4	1	2	1
23/04/96	22	6	0	1	—
24/04/96	24	2	4	3	2
25/04/96	25	3	5	2	—
26/04/96	28	4	2	—	—
27/04/96	22	7	2	—	—
29/04/96	18	2	4	2	—
30/04/96	26	3	5	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
April, 1996 Name of Tipsite Castlerea

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/04/96	22	4	2	—	—
02/04/96	18	2	3	1	1
03/04/96	26	3	1	2	—
04/04/96	20	5	4	3	—
05/04/96	21	2	1	2	—
06/04/96	25	3	3	2	—
08/04/96	23	2	4	1	—
09/04/96	17	1	2	—	1
10/04/96	26	0	1	2	—
11/04/96	22	4	—	4	—
12/04/96	19	3	2	—	—
13/04/96	26	5	3	—	2
15/04/96	28	1	—	2	—
16/04/96	22	3	4	1	—
17/04/96	20	4	6	3	—
18/04/96	19	5	2	0	—
19/04/96	22	2	4	1	—
20/04/96	24	1	2	—	—
22/04/96	21	4	1	2	1
23/04/96	22	6	0	1	—
24/04/96	24	2	4	3	2
25/04/96	25	3	5	2	—
26/04/96	28	4	2	—	—
27/04/96	22	7	2	—	—
29/04/96	18	2	4	2	—
30/04/96	26	3	5	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
March, 1996 Name of Tipsite [redacted] Roo

DATE	NUMBER OF USERS PER DAY				
	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/03/96	24	3	2	—	1
02/03/96	20	4	1	—	—
04/03/96	17	3	0	—	—
05/03/96	19	8	3	1	—
06/03/96	20	2	1	—	—
07/03/96	24	4	1	—	2
08/03/96	26	3	3	2	—
09/03/96	22	6	4	—	—
11/03/96	20	4	3	—	—
12/03/96	23	5	2	—	—
13/03/96	21	4	4	2	—
14/03/96	19	6	3	—	—
15/03/96	18	3	4	—	1
16/03/96	22	5	1	—	—
18/03/96	24	4	3	—	—
19/03/96	20	5	3	—	—
20/03/96	21	6	4	1	—
21/03/96	25	7	5	—	2
22/03/96	27	3	2	—	—
23/03/96	20	2	2	1	—
25/03/96	19	7	1	—	1
26/03/96	20	6	—	—	—
27/03/96	23	4	4	1	—
28/03/96	26	5	3	—	—
29/03/96	22	6	6	—	—
30/03/96	21	7	3	—	1
	—	—	—	2	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
February, 1996 NAME OF TIPSITE : Lee

NUMBER OF USERS PER DAY					
DATE	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
01/02/96	19	2	2	—	—
02/02/96	23	3	1	—	—
03/02/96	22	5	—	2	—
05/02/96	20	2	3	—	1
06/02/96	19	6	—	1	—
07/02/96	14	4	4	—	—
08/02/96	15	2	3	—	2
09/02/96	24	1	1	—	—
10/02/96	21	2	2	1	—
12/02/96	20	—	1	—	1
13/02/96	19	4	—	—	—
14/02/96	21	6	4	3	1
15/02/96	24	5	5	—	—
16/02/96	22	3	2	—	—
17/02/96	16	5	1	2	—
19/02/96	19	2	4	—	—
20/02/96	23	6	3	—	—
21/02/96	22	1	2	—	2
22/02/96	23	3	2	1	—
23/02/96	20	2	1	—	—
24/02/96	19	4	3	3	—
26/02/96	17	3	0	—	2
27/02/96	26	8	5	—	—
28/02/96	21	6	1	—	—
29/02/96	23	2	2	—	—
	[illegible]	[illegible]	[illegible]	—	—
	[illegible]	[illegible]	[illegible]	—	—

Use of Council Tipsites for disposal of domestic refuse by private individuals
January, 1996 NAME of TIPSITE Roe

DATE	NUMBER OF USERS PER DAY				
	CAR	CAR & TRAILER	VAN	VAN & TRAILER	TRACTOR & TRAILER
02/01/96	36	9	3	—	—
03/01/96	28	4	1	—	—
04/01/96	21	5	3	—	—
05/01/96	25	1	2	—	—
06/01/96	18	4	2	2	1
08/01/96	20	2	3	0	0
09/01/96	19	1	1	2	—
10/01/96	24	3	3	—	—
11/01/96	17	—	2	—	—
12/01/96	26	—	2	1	1
13/01/96	20	—	—	—	—
14/01/96	19	6	3	0	0
16/01/96	22	4	2	0	—
17/01/96	25	3	1	0	1
18/01/96	20	2	3	0	—
19/01/96	21	4	—	0	—
20/01/96	17	5	2	0	—
21/01/96	23	2	4	2	—
23/01/96	26	1	1	0	2
24/01/96	18	6	6	0	1
25/01/96	20	4	2	1	—
26/01/96	22	2	—	0	1
27/01/96	17	4	2	1	—
28/01/96	24	4	—	0	—
30/01/96	19	5	4	0	2
31/01/96	21	3	2	2	—
	23	6	1	0	—

APPENDIX B

BOREHOLE LOGS AND CONSTRUCTION DETAILS MEASURED LEACHATE AND GROUNDWATER LEVELS

(7 Pages)

Entec

Table B.1

Groundwater and Leachate Levels

Borehole	Borehole Level (m SD)	Type	Depth (m)	Water Level (m SD)	
				September 1998	December 1998
CBH1	80.0	Leachate	5.00	77.64	77.97
CBH2	80.0	Leachate	4.00	79.20	-
CBH3	77.31	Groundwater	5.00	76.67	76.74
CBH4	78.85	Groundwater	6.00	76.95	77.22
CBH5	79.32	Leachate	5.00	77.10	77.28
CBH6	79.65	Groundwater	6.50	77.49	77.64

Entec

Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	

Borehole **CBH1**

Sheet 1 of 1

Ground Level m AOD

Co-Ordinates: E N

Date Drilled: 26.08.98 - 26.08.98

Depth mbgl	Borehole Log / Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
	Moderately firm, red/brown, silty BOULDER CLAY capping		(0.70) 0.70					
1	Loose to moderately firm, black, dark brown, mixed WASTE with clayey matrix							
2			(3.00)					
3	Slow leachate seepage		3.70		▼			
4	Moderately soft, dark brown, fibrous PEAT		(1.30)					
5			5.00					
6								
7								
8								
9								
10								

General Remarks: **Borehole drilled as gas/leachate monitoring point in central southern part of area A1 in recently landfilled waste**

Logged By: **CNR** | All Dimensions in Metres | Scale: **1:50**

Entec

Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	

Borehole **CBH2**

Sheet 1 of 1

Ground Level m AOD

Co-Ordinates: E N

Date Drilled: 27.08.98 - 27.08.98

Depth mbgl	Borehole Log – Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
0	Moderately firm, brown, red/brown, silty BOULDER CLAY capping		(0.20)					
	Moderately firm, occasionally loose, dark grey, black, mixed WASTE comprising domestic waste with binliners of rotting organic matter, paper, plastic etc..		(0.90)					
1	Moderately soft, dark brown, fibrous PEAT		1.10		▼			
2			(2.90)					
3								
4			4.00					
5								
6								
7								
8								
9								
10								

General Remarks: **Borehole drilled as leachate/gas monitoring point in northern part of the western area of the site. Drilled through recently landfilled waste.**

Logged By: **MT** | All Dimensions in Metres | Scale: **1:50**

Entec

Borehole	**CBH3**
Sheet	1 of 1
Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Ground Level	m AOD
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	
Co-Ordinates:	E N
Date Drilled:	26.08.98 - 26.08.98

Depth mbgl	Borehole Log – Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
0	Moderately soft to soft, dark brown, fibrous PEAT		(3.60)		▼	B		
3.60	Soft to moderately firm, grey, very silty BOULDER CLAY		(1.40)			B		
5.00								

General Remarks: **Borehole drilled as groundwater monitoring point in area of peat in the north-west corner of the site**

Logged By: **MT**	All Dimensions in Metres	Scale: **1:50**

Entec

Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	

Borehole **CBH4**

Sheet 1 of 1

Ground Level m AOD

Co-Ordinates: E N

Date Drilled: 27.08.98 - 27.08.98

Depth mbgl	Borehole Log – Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
	Moderately firm, brown, grey/brown, silty BOULDER CLAY capping		(0.40) 0.40					
1	Moderately firm, occasionally loose, black, dark grey, mixed WASTE comprising predominantly rotted organic matter, occasional wood, paper, plastic bags and metal		(3.80)		▼			
4			4.20					
5	Soft to moderately firm, grey, grey/brown, silty to very silty BOULDER CLAY		(1.80)					
6			6.00					
7								
8								
9								
10								

General Remarks: **Borehole drilled as groundwater monitoring point at northern end of the eastern area of the site**

Logged By: **MT** | All Dimensions in Metres | Scale: **1:50**

Entec

Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	

Borehole **CBH5**

Sheet 1 of 1

Ground Level m AOD

Co-Ordinates: E N

Date Drilled: 28.08.98 - 29.08.98

Depth mbgl	Borehole Log / Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
	Moderately firm, grey/brown, red/brown, silty BOULDER CLAY capping		(0.80)					
			0.80					
1	Loose to occasionally firm, black, grey/brown, mixed WASTE comprising mainly well rotted domestic waste							
2			(3.20)		▼			
3								
4			4.00					
	Soft, dark brown, brown, fibrous PEAT		(1.00)					
5			5.00					
6								
7								
8								
9								
10								

General Remarks: **Borehole drilled as gas/leachate monitoring point in central part of the eastern area of the site in oldest area of landfilled waste**

Logged By: **MT** | All Dimensions in Metres | Scale: **1:50**

Entec

Project:	Castlerea Landfill SI
Client:	Roscommon County Council
Project No:	19428
Contractor :	IGSL
Diameter:	150 mm
Method :	Shell and Auger
Rig Type:	

Borehole **CBH6**

Sheet 1 of 1

Ground Level m AOD

Co-Ordinates: E N

Date Drilled: 28.08.98 - 29.08.98

Depth mbgl	Borehole Log – Strata Description	Legend	Depth (Thick-ness)	mAOD	Water Strikes	Sample Type	Sample Data	Piezo.
	Moderately firm, compacted, brown, silty BOULDER CLAY capping		(0.50) 0.50					
1	Loose, black, grey/brown, well rotted WASTE comprising black binliners of domestic waste, wood, metal fragments, occasional glass etc..		(2.00)		▼			
2			2.50					
3	Soft, dark brown, fibrous PEAT		(2.30)					
4			4.80					
5	Moderately firm, occasionally soft, grey, grey/brown, very silty BOULDER CLAY with occasional fine gravel		(0.90) 5.70					
6	Moderately firm, grey, silty, sandy, gravelly BOULDER CLAY with cobbles and boulders		(0.80) 6.50					
7								
8								
9								
10								

General Remarks: **Borehole drilled as groundwater monitoring point at southern end of eastern part of the landfill, encountered waste deposits which were sealed off prior to entering natural ground**

Logged By: MT	All Dimensions in Metres	Scale: 1:50

APPENDIX C

LABORATORY RESULTS OF CHEMICAL ANALYSIS (PREFIX C = CASTLEREA)

(9 Pages)

Pages 1-5 December 1998 Samples
Pages 6-9 September 1998 Samples

Entec

CAL

CHEMICAL ANALYSIS LABORATORY
Department of Biochemistry Trinity College Dublin 2 Ireland
Tel. (Dublin) 6081574/6714657 Fax. (Dublin) 6772400

CHEMICAL ANALYSIS REPORT

Atten : Mr. Clive Rivers,
Entec UK Ltd.,
160-162 Abbey Foregate,
Shrewsbury,
Shropshire,
SY2 6BZ,
England.

19428 KL 233.

ENREAF

No. of Samples : 31 **Your Ref.** : SHR-9730

Invoice No. : 5455 **Our Ref.** : W6444

Signed : _____ **Countersigned** : _____

Date Reported : 05/01/99

N.B. Please note that our second telephone line is 6714657.

Note : Any services by CAL are provided strictly subject to the limitations of liability as stated overleaf and this Report is issued solely on that basis.

OUR REF. : W6444
LAB NO.'S : 17732-17762

Sample I.D.	pH	B.O.D. (mg/l)	C.O.D. (mg/l)	D.O. (%)	Calcium (mg/l)	Conductivity 20°C (μScm^{-1})	Cyanide (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Magnesium (mg/l)
CSW1	7.9	32.5	775.3	12	120	8250	--	--	0.81	59.8
CSW2	7.6	3.5	85.8	29	126	2030	--	--	0.30	37.3
CSW3	7.6	<1.0	70.4	75	71.2	360	--	--	0.32	3.37
SSW1	8.1	10.0	1037.9	16	183	7040	--	--	0.40	172
SSW2	7.5	5.0	43.0	15	218	1950	--	--	0.23	85.0
SSW3	7.1	7.0	61.7	69	137	780	--	--	0.41	7.53
Bala SW1	7.3	1.0	40.2	63	49.0	411	--	--	0.33	5.20
Bala SW2	7.4	<1.0	59.9	77	19.2	140	--	--	0.64	1.31
Bala SW3	6.1	8.0	93.2	16	9.39	136	--	--	0.98	2.35
Bala SW4	7.1	1.0	36.1	70	47.0	265	--	--	0.32	2.30
BSW1	7.3	12.5	513.3	15	186	4180	--	--	13.3	91.8
BSW2	6.8	2.0	105.0	40	24.3	206	--	--	1.48	3.42
BSW3	7.4	5.0	118.0	18	41.0	871	--	--	0.26	13.7
BBH1	6.8	7.5	238.5	--	156	2730	--	--	24.7	68.5
BBH3	7.3	50.0	2406.0	--	212	12100	--	--	5.5	241
Bala BH4	7.3	30.0	602.7	--	130	6370	--	--	12.0	200
Bala BH5	6.8	7.5	306.7	--	419	3000	--	--	3.11	49.8
Bala BH6	7.1	10.0	264.1	--	273	4970	--	--	1.98	132
Bala BH7	7.0	18.5	114.0	--	245	3150	--	--	4.49	96.2
CBH1	7.6	450.0	3301.0	--	10.7	21900	--	--	1.99	113
CBH5	7.6	35.0	291.8	--	61.2	5470	--	--	0.94	93.4
SBH5	7.1	9.0	44.0	--	236	1930	--	--	9.9	66.5
Bala BH1	7.1	--	--	20	181	788	<0.01	0.23	1.72	4.83
Bala BH2	6.8	--	--	17	175	875	<0.01	0.1	0.52	8.12
Bala BH3	6.7	--	--	22	185	735	<0.01	0.16	7.3	3.01
BBH56	6.7	--	--	18	244	1080	<0.01	0.14	0.67	24.4
CBH3	6.9	--	--	17	193	904	<0.01	0.14	0.49	4.16
CBH4	7.0	--	--	12	200	1890	<0.01	0.11	9.3	31.3
CBH6	7.0	--	--	16	221	1300	<0.01	0.1	3.37	19.1
SBH2	7.4	--	--	14	197	5500	<0.01	0.11	5.4	244
SBH6	7.1	--	--	22	369	2040	<0.01	0.11	6.8	41.1

OUR REF : W6444
LAB NO.'S : 17732-17762

Sample I.D.	Mercury (μg/l)	Total Monohydric Phenols (mg/l)	Sodium (mg/l)	Total Solids (mg/l)	Alkalinity (mg/l)	Potassium (mg/l)	Ammoniacal N (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Boron (mg/l)
CSW1	<0.02	--	620	--	2700	220	618	--	--	--
CSW2	0.09	--	100	--	810	37.8	118	--	--	--
CSW3	0.29	--	9.50	--	148	1.41	0.1	--	--	--
SSW1	0.03	--	640	--	250	450	213	--	--	--
SSW2	0.03	--	110	--	690	120	21.1	--	--	--
SSW3	<0.02	--	17.2	--	340	11.7	3.4	--	--	--
Bala SW1	0.07	--	21.1	--	134	7.32	1.3	--	--	--
Bala SW2	<0.02	--	7.38	--	44	0.84	0.1	--	--	--
Bala SW3	0.06	--	11.9	--	26	5.01	1.2	--	--	--
Bala SW4	0.02	--	7.08	--	115	1.07	0.2	--	--	--
BSW1	0.03	--	240	--	1950	220	247	--	--	--
BSW2	0.14	--	9.40	--	73	5.01	2.2	--	--	--
BSW3	<0.02	--	58	--	180	48.3	15.1	--	--	--
BBH1	0.11	--	11.0	--	1300	95	156	--	--	--
BBH3	<0.02	--	970	--	5250	1100	837	--	--	--
Bala BH4	<0.02	--	510	--	1950	230	250	--	--	--
Bala BH5	<0.02	--	160	--	1500	98	83.6	--	--	--
Bala BH6	<0.02	--	450	--	750	200	144	--	--	--
Bala BH7	<0.02	--	220	--	1050	89	88.9	--	--	--
CBH1	<0.02	--	1400	--	1170	450	36.2	--	--	--
CBH5	<0.02	--	170	--	1625	88	710	--	--	--
SBH5	<0.02	--	80	--	600	95	17.9	--	--	--
Bala BH1	<0.02	<0.05	19.9	1486	350	2.79	8.9	<0.005	0.36	<0.05
Bala BH2	<0.02	0.08	17.8	1706	420	0.99	0.6	<0.005	0.14	<0.05
Bala BH3	<0.02	0.10	9.86	5267	310	0.61	2.3	<0.005	0.09	<0.05
BBH56	<0.02	<0.05	24.2	2406	430	2.16	1.0	<0.005	0.59	<0.05
CBH3	<0.02	<0.05	23.7	30000	335	3.26	8.5	<0.005	0.21	<0.05
CBH4	<0.02	<0.05	23.6	2312	690	25.8	136	0.007	0.09	0.23
CBH6	<0.02	<0.05	78	915	450	6.40	1.4	<0.005	0.31	<0.05
SBH2	<0.02	<0.05	320	3600	2500	330	263	<0.005	0.29	1.57
SBH6	<0.02	<0.05	120	2725	520	26.4	10.8	0.019	0.34	0.26

OUR REF. : W6444
LAB NO.'S : 17732-17762

Sample I.D.	Cadmium (mg/l)	Chloride (mg/l)	Chromium (mg/l)	Copper (mg/l)	Lead (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Phosphorus (mg/l)	Selenium (mg/l)	Silver (mg/l)
CSW1	<0.005	1200	0.04	<0.01	<0.05	0.21	<0.03	--	--	--
CSW2	<0.005	167	<0.01	<0.01	<0.05	0.17	<0.03	--	--	--
CSW3	<0.005	22	<0.01	<0.01	0.05	0.02	<0.03	--	--	--
SSW1	<0.005	1020	0.06	<0.01	0.07	0.82	<0.03	--	--	--
SSW2	<0.005	162	<0.01	0.01	<0.05	1.36	<0.03	--	--	--
SSW3	<0.005	42	<0.01	<0.01	<0.05	0.14	<0.03	--	--	--
Bala SW1	<0.005	46	<0.01	0.01	<0.05	0.02	<0.03	--	--	--
Bala SW2	<0.005	20	<0.01	0.02	<0.05	<0.01	<0.03	--	--	--
Bala SW3	<0.005	32	<0.01	0.01	<0.05	0.05	<0.03	--	--	--
Bala SW4	<0.005	19	<0.01	0.01	<0.05	<0.01	<0.03	--	--	--
BSW1	<0.005	396	0.02	<0.01	<0.05	1.39	0.03	--	--	--
BSW2	<0.005	25	<0.01	0.01	<0.05	0.16	<0.03	--	--	--
BSW3	<0.005	105	<0.01	0.02	<0.05	0.22	<0.03	--	--	--
BBH1	<0.005	155	<0.01	0.01	<0.05	0.91	<0.03	--	--	--
BBH3	<0.005	1340	0.23	<0.01	<0.05	0.80	0.14	--	--	--
Bala BH4	<0.005	1030	<0.01	0.02	<0.05	3.25	0.07	--	--	--
Bala BH5	<0.005	249	<0.01	<0.01	<0.05	4.41	<0.03	--	--	--
Bala BH6	<0.005	741	<0.01	<0.01	<0.05	0.61	<0.03	--	--	--
Bala BH7	<0.005	345	<0.01	<0.01	<0.05	0.69	<0.03	--	--	--
CBH1	<0.005	1610	0.02	0.02	<0.05	0.02	0.11	--	--	--
CBH5	<0.005	351	<0.01	<0.01	<0.05	0.41	0.22	--	--	--
SBH5	<0.005	130	<0.01	<0.01	<0.05	0.89	<0.03	--	--	--
Bala BH1	<0.005	35	<0.01	<0.01	<0.05	0.40	<0.03	<0.1	0.004	<0.01
Bala BH2	<0.005	20	<0.01	<0.01	<0.05	2.91	<0.03	<0.1	0.003	<0.01
Bala BH3	<0.005	19	<0.01	0.01	<0.05	1.39	<0.03	<0.1	0.003	<0.01
BBH56	<0.005	25	<0.01	<0.01	<0.05	4.04	<0.03	<0.1	<0.002	<0.01
CBH3	<0.005	45	<0.01	<0.01	<0.05	0.12	<0.03	<0.1	<0.002	<0.01
CBH4	<0.005	50	<0.01	<0.01	<0.05	1.37	0.05	0.26	<0.002	<0.01
CBH6	<0.005	74	<0.01	<0.01	<0.05	2.10	<0.03	<0.1	<0.002	<0.01
SBH2	<0.005	456	<0.01	0.02	<0.05	0.60	<0.03	0.24	<0.002	<0.01
SBH6	<0.005	79	<0.01	<0.01	<0.05	1.35	<0.03	<0.1	<0.002	<0.01

OUR REF. : W6444
LAB NO.'S : 17732-17762

Sample I.D.	Sulphate (mg/l)	Total Organic Carbon (mg/l)	Total Oxidised Nitrogen (mg/l)	Zinc (mg/l)
CSW1	63	230	0.33	0.06
CSW2	24	32	0.72	0.03
CSW3	15	25	3.54	0.01
SSW1	54	290	0.13	0.06
SSW2	247	19	<0.05	0.01
SSW3	16	18	3.59	0.02
Bala SW1	16	15	2.68	0.02
Bala SW2	19	21	0.24	0.01
Bala SW3	23	30	<0.05	0.02
Bala SW4	16	12	0.25	<0.01
BSW1	59	130	0.05	0.03
BSW2	21	33	0.29	0.04
BSW3	18	37	20.3	0.03
BBH1	39	58	<0.05	0.03
BBH3	71	550	0.19	0.06
Bala BH4	373	96	0.05	0.01
Bala BH5	23	89	<0.05	0.02
Bala BH6	104	65	<0.05	<0.01
Bala BH7	24	41	<0.05	<0.01
CBH1	52	650	0.48	0.06
CBH5	48	64	0.07	<0.01
SBH5	180	15	<0.05	0.01
Bala BH1	14	10	0.35	0.04
Bala BH2	14	8.7	<0.05	0.02
Bala BH3	76	35	0.12	<0.01
BBH56	14	28	<0.05	<0.01
CBH3	15	9.8	0.23	0.01
CBH4	29	21	<0.05	0.02
CBH6	57	17	0.05	0.16
SBH2	21	78	<0.05	<0.01
SBH6	414	16	<0.05	0.03

CAL

CHEMICAL ANALYSIS LABORATORY

Department of Biochemistry Trinity College Dublin 2 Ireland
Tel. (Dublin) 6081574/6714657 Fax. (Dublin) 6772400

SAMPLE DESCRIPTION : Ballaghdereen Study

OUR REF : W6264

LAB NO.'S : 17113-17134 + 17311

Sample I.D.	pH	B.O.D. (mg/l)	C.O.D. (mg/l)	D.O. (%)	Calcium (mg/l)	Conductivity 20°C (μScm^{-1})	Cyanide (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Magnesium (mg/l)
CBH3	7.0	--	--	27	146	1142	<0.025	0.21	10.2	6.85
CBH4	7.3	--	--	24	189	4960	<0.025	0.15	9.3	71.7
BBH56	6.8	--	--	23	229	1076	<0.025	0.07	4.07	24.1
CBH6	7.0	--	--	23	151	1317	<0.025	0.06	0.85	18.0
SBH2	7.4	--	--	23	198	5330	<0.025	0.07	3.82	217
SBH6	7.0	--	--	22	281	2060	<0.025	0.07	6.0	38.9
BSW1	7.3	10	362.1	25	158	3110	--	--	1.51	68.7
BSW2	6.8	10	264.1	23	54.7	530	--	--	9.4	9.82
BSW3	7.2	<2.5	232.1	22	60.6	1117	--	--	2.28	16.6
CSW1	8.0	<10	1448.0	43	170	10540	--	--	1.18	76.6
CSW2	7.6	<2.5	189.5	22	112	1802	--	--	1.23	31.4
CSW3	7.6	<1.0	70.9	54	96.9	478	--	--	0.69	4.46
SSW1	7.3	5.0	273.7	24	128	2340	--	--	0.26	38.7
SSW2	7.5	13.5	106.0	24	165	2020	--	--	0.27	58.9
SSW3	6.6	10.0	60.9	32	170	697	--	--	8.2	6.43
BBH1	6.8	25	302.4	--	156	2640	--	--	48	63.6
BBH2	7.1	115	1086	--	253	6120	--	--	31	149
BBH3	7.5	50	2705	--	197	11690	--	--	15	219
CBH1	7.5	925	4494	--	191	15720	--	--	3.46	140
CBH2	7.3	300	2492	--	415	2290	--	--	8.7	293
CBH5	7.7	82.5	722	--	58.7	9530	--	--	11	92.7
SBH1	7.4	10	108	--	96.0	2310	--	--	11	89.0
SBH5	7.2	5	50.7	--	136	1782	--	--	11	59.5

CAL

CHEMICAL ANALYSIS LABORATORY

Department of Biochemistry Trinity College Dublin 2 Ireland

Tel. (Dublin) 6081574/6714657 Fax. (Dublin) 6772400

SAMPLE DESCRIPTION : Ballaghdereen Study

OUR REF : W6264

LAB NO.'S : 17113-17134 + 17311

Sample I.D.	Mercury (µg/l)	Total Monohydric Phenols (mg/l)	Sodium (mg/l)	Total Solids (mg/l)	Alkalinity (mg/l)	Potassium (mg/l)	Ammoniacal N (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Boron (mg/l)
CBH3	0.07	0.08	120	1762	495	9.92	17.0	0.024	0.20	0.16
CBH4	<0.02	0.07	140	1183	2550	68	501	0.012	0.15	0.97
BBH56	<0.02	0.37	57	705	740	4.05	0.9	0.006	0.53	0.13
CBH6	<0.02	0.05	89	731	645	7.91	17.9	<0.005	0.21	0.16
SBH2	1.3	0.07	320	2838	2650	340	230	0.006	0.36	1.64
SBH6	<0.02	0.14	260	1546	650	29.9	11.4	0.019	0.35	0.41
BSW1	0.03	--	--	180	1375	150	109	--	--	--
BSW2	0.04	--	--	24.3	245	8.78	5.8	--	--	--
BSW3	0.05	--	--	80	280	60	3.1	--	--	--
CSW1	0.04	--	--	900	3650	400	591	--	--	--
CSW2	0.05	--	--	130	640	46.2	61.1	--	--	--
CSW3	<0.02	--	--	12.6	240	1.28	0.3	--	--	--
SSW1	0.05	--	--	180	700	140	33.1	--	--	--
SSW2	0.02	--	--	130	790	110	16.3	--	--	--
SSW3	0.20	--	--	10.9	354	7.94	1.3	--	--	--
BBH1	<0.02	--	97	--	1375	89	122	--	--	--
BBH2	<0.02	--	360	--	3075	300	396	--	--	--
BBH3	<0.02	--	900	--	6400	1000	945	--	--	--
CBH1	<0.02	--	1400	--	7800	420	1836	--	--	--
CBH2	0.05	--	3500	--	4550	460	641	--	--	--
CBH5	0.10	--	460	--	4700	220	831	--	--	--
SBH1	0.03	--	160	--	1125	120	57.2	--	--	--
SBH5	<0.02	--	65	--	750	89	33.7	--	--	--

CAL

CHEMICAL ANALYSIS LABORATORY

Department of Biochemistry Trinity College Dublin 2 Ireland
Tel. (Dublin) 6081574/6714657 Fax. (Dublin) 6772400

SAMPLE DESCRIPTION : Ballaghdereen Study

OUR REF : W6624

LAB NO.'S : 17113-17134 + 17311

Sample I.D.	Cadmium (mg/l)	Chloride (mg/l)	Chromium (mg/l)	Copper (mg/l)	Lead (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Total Phosphate (mg/l)	Selenium (mg/l)	Silver (mg/l)
CBH3	<0.05	92	0.03	0.05	<0.05	0.20	0.12	0.14	<0.002	<0.01
CBH4	<0.05	90	<0.03	0.04	<0.05	0.90	0.04	1.07	<0.002	<0.01
BBH56	<0.05	29	<0.03	0.06	<0.05	1.61	0.03	0.42	<0.002	<0.01
CBH6	<0.05	71	<0.03	<0.01	<0.05	0.77	<0.03	<0.1	<0.002	<0.01
SBH2	<0.05	425	<0.03	<0.01	<0.05	0.51	<0.03	0.84	<0.002	<0.01
SBH6	<0.05	90	<0.03	0.08	<0.05	0.46	<0.03	0.70	<0.002	<0.01
BSW1	<0.005	311	<0.03	<0.01	<0.05	2.31	<0.03	--	--	--
BSW2	0.007	58	<0.03	<0.01	<0.05	0.62	<0.03	--	--	--
BSW3	<0.005	168	<0.03	0.02	<0.05	5.7	<0.03	--	--	--
CSW1	0.006	1880	0.06	0.04	<0.05	0.15	0.05	--	--	--
CSW2	<0.005	235	<0.03	0.01	<0.05	0.52	<0.03	--	--	--
CSW3	<0.005	27	<0.03	<0.01	<0.05	0.70	<0.03	--	--	--
SSW1	<0.005	409	<0.03	<0.01	<0.05	0.35	<0.03	--	--	--
SSW2	0.006	224	<0.03	0.06	<0.05	0.35	<0.03	--	--	--
SSW3	<0.005	34	<0.03	<0.01	<0.05	0.48	<0.03	--	--	--
BBH1	<0.005	142	<0.03	0.02	<0.05	1.32	<0.03	--	--	--
BBH2	0.006	656	<0.03	0.03	<0.05	1.58	0.05	--	--	--
BBH3	0.005	1440	0.27	0.04	<0.05	0.69	0.12	--	--	--
CBH1	0.007	2080	<0.03	0.03	<0.05	0.56	0.08	--	--	--
CBH2	<0.005	6490	<0.03	0.07	<0.05	0.98	0.03	--	--	--
CBH5	<0.005	774	<0.03	0.05	0.05	0.88	0.05	--	--	--
SBH1	<0.005	131	<0.03	0.03	<0.05	0.41	<0.03	--	--	--
SBH5	<0.005	132	<0.03	0.02	<0.05	1.10	<0.03	--	--	--

CAL

CHEMICAL ANALYSIS LABORATORY
Department of Biochemistry Trinity College Dublin 2 Ireland
Tel. (Dublin) 6081574/6714657 Fax. (Dublin) 6772400

SAMPLE DESCRIPTION : Ballaghdereen Study

OUR REF : W6264

LAB NO.'S : 17113 – 17134 + 17311

Sample I.D.	Sulphate (mg/l)	Total Organic Carbon (mg/l)	Total Oxidised Nitrogen (mg/l)	Zinc (mg/l)
CBH3	126	22	0.10	0.15
CBH4	23	120	0.16	0.05
BBH56	<10	34	0.15	0.06
CBH6	<10	19	1.42	0.10
SBH2	12	120	<0.05	0.03
SBH6	41	23	0.21	0.07
BSW1	380	98	1.17	0.04
BSW2	12	49	<0.05	0.03
BSW3	15	70	3.0	0.04
CSW1	48	410	0.38	0.15
CSW2	46	97	0.87	0.03
CSW3	14	31	0.12	<0.01
SSW1	<10	120	<0.05	0.03
SSW2	77	40	<0.05	0.06
SSW3	14	81	0.69	0.02
BBH1	133	67	<0.05	0.06
BBH2	<10	300	0.07	0.62
BBH3	27	730	0.37	0.24
CBH1	103	950	0.13	0.20
CBH2	42	350	0.37	0.36
CBH5	91	190	0.22	0.27
SBH1	43	30	0.09	0.07
SBH5	10	15	0.28	0.02

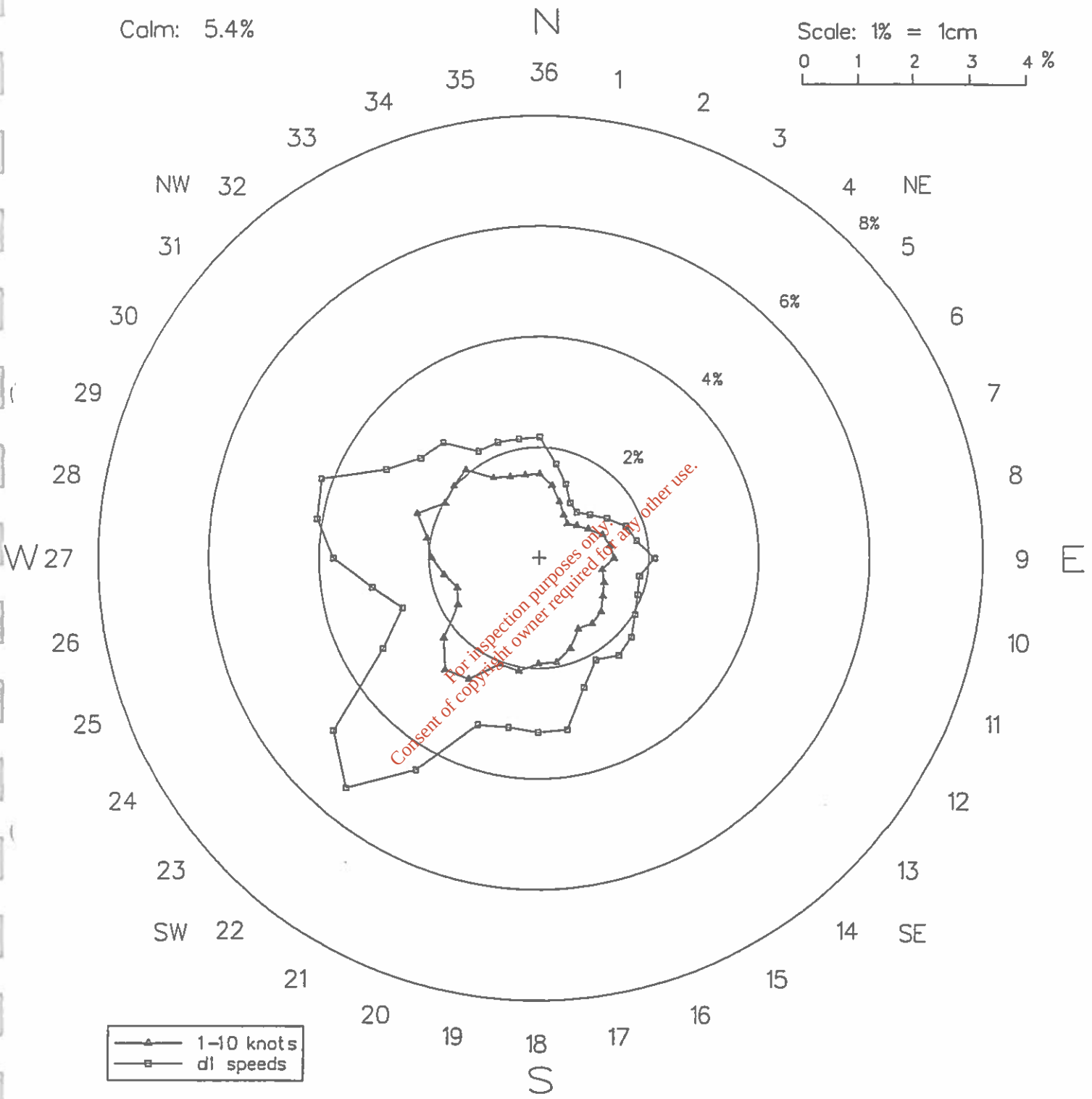
APPENDIX D

METEOROLOGICAL DATA

(5 Pages)

CLAREMORRIS 1961–1990

Percentage Frequency of Occurrence of Wind Directions



Percentage Frequency of Occurrence of Wind Speeds

+ less than 0.1

0	1–3	4–6	7–10	11–16	17–21	22–27	28–33	34–40	41–47	over 48	knots
5.4	13.9	18.8	26.6	25.9	6.8	2.2	0.3	+	+	+	%

mean wind speed: 8.8 knots

standard deviation: 5.7 knots

anemometer height: 12m

Meteorological Service, Glasnevin Hill, Dublin 9.

number of simultaneous occurrences of specified ranges of mean hourly wind speed and direction

Claremorris — all months (january 1961 to december 1990)

direction in degrees	wind speed in knots												
	calm	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	56-63	over 63	total
010		830	1235	1434	913	126	12							4550
020		700	992	1161	724	139	29	2						3747
030		706	768	893	552	79	24							3022
040		631	690	815	593	89	25	1						2844
050		726	826	853	635	153	23	2						3218
060		707	900	1156	787	188	37	4						3779
070		911	1071	1288	900	196	70	3						4439
080		940	1218	1329	1001	208	65	4						4765
090		973	1256	1390	1317	430	152	8						5526
100		770	1030	1315	1274	388	138	4						4919
110		875	1055	1442	1259	329	103	9						5072
120		937	1081	1574	1308	363	95	9						5367
130		935	1180	1836	1522	315	47	2						5837
140		993	1247	1820	1590	315	68	1						6034
150		998	1178	1706	1406	260	42							5590
160		1096	1435	2040	1631	296	48	3						6549
170		1104	1572	2359	2533	557	164	9	1					8299
180		1109	1615	2315	2444	634	180	9		1				8307
190		1256	1842	2363	2215	412	100	5		1				8194
200		1119	1794	2471	2284	580	190	19	3		1			8461
210		1207	2012	3440	3441	1099	345	90	6			1		11641
220		1041	1856	4043	5003	1620	570	122	7	4	2			14268
230		1001	1628	3289	4756	1522	483	74	5	1				12759
240		915	1272	2269	2884	920	282	35	8					8585
250		819	1312	2023	2047	510	196	26	6					6939
260		968	1468	2179	2485	696	229	53	8	2				8088
270		1096	1568	2472	3063	1093	404	106	13	4				9819
280		1137	1629	2678	3535	1166	470	113	26	14				10768
290		1370	1861	2953	3477	966	350	68	19	2				11066
300		1356	1620	2228	2288	603	288	46	8					8437
310		1581	1924	1820	1503	404	138	22	7					7399
320		1838	1961	1668	1274	293	85	28	1					7148
330		1309	1451	1633	1139	252	69	5						5858
340		962	1327	1832	1394	261	64	8	1					5849
350		837	1237	1929	1474	218	47	7						5749
360		814	1214	1973	1515	198	31	1						5746
total	14330	36567	49325	69989	68166	17878	5663	898	119	29	3	1		262968

percentage frequency of simultaneous occurrences of specified ranges of mean hourly wind speed and direction

Claremorris all months (january 1961 to december 1990)

direction in degrees	calm	wind speed in knots 1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	56-63	over 63	total
010		0.3	0.5	0.5	0.3	0+	0+							1.7
020		0.3	0.4	0.4	0.3	0.1	0+	0+						1.4
030		0.3	0.3	0.3	0.2	0+	0+							1.1
040		0.2	0.3	0.3	0.2	0+	0+	0+						1.1
050		0.3	0.3	0.3	0.2	0.1	0+	0+						1.2
060		0.3	0.3	0.4	0.3	0.1	0+	0+						1.4
070		0.3	0.4	0.5	0.3	0.1	0+	0+						1.7
080		0.4	0.5	0.5	0.4	0.1	0+	0+						1.8
090		0.4	0.5	0.5	0.5	0.2	0.1	0+						2.1
100		0.3	0.4	0.5	0.5	0.1	0.1	0+						1.9
110		0.3	0.4	0.5	0.5	0.1	0+	0+						1.9
120		0.4	0.4	0.6	0.5	0.1	0+	0+						2.0
130		0.4	0.4	0.7	0.6	0.1	0+	0+						2.2
140		0.4	0.5	0.7	0.6	0.1	0+	0+						2.3
150		0.4	0.4	0.6	0.5	0.1	0+							2.1
160		0.4	0.5	0.8	0.6	0.1	0+	0+						2.5
170		0.4	0.6	0.9	1.0	0.2	0.1	0+	0+					3.2
180		0.4	0.6	0.9	0.9	0.2	0.1	0+		0+				3.2
190		0.5	0.7	0.9	0.8	0.2	0+	0+		0+				3.1
200		0.4	0.7	0.9	0.9	0.2	0.1	0+	0+		0+			3.2
210		0.5	0.8	1.3	1.3	0.4	0.1	0+	0+			0+		4.4
220		0.4	0.7	1.5	1.9	0.6	0.2	0+	0+	0+	0+			5.4
230		0.4	0.6	1.3	1.8	0.6	0.2	0+	0+	0+				4.9
240		0.3	0.5	0.9	1.1	0.3	0.1	0+	0+					3.3
250		0.3	0.5	0.8	0.8	0.2	0.1	0+	0+					2.6
260		0.4	0.6	0.8	0.9	0.3	0.1	0+	0+	0+				3.1
270		0.4	0.6	0.9	1.2	0.4	0.2	0+	0+	0+				3.7
280		0.4	0.6	1.0	1.3	0.4	0.2	0+	0+	0+				4.1
290		0.5	0.7	1.1	1.3	0.4	0.1	0+	0+	0+				4.2
300		0.5	0.6	0.8	0.9	0.2	0.1	0+	0+					3.2
310		0.6	0.7	0.7	0.6	0.2	0.1	0+	0+					2.8
320		0.7	0.7	0.6	0.5	0.1	0+	0+	0+					2.7
330		0.5	0.6	0.6	0.4	0.1	0+	0+						2.2
340		0.4	0.5	0.7	0.5	0.1	0+	0+	0+					2.2
350		0.3	0.5	0.7	0.6	0.1	0+	0+						2.2
360		0.3	0.5	0.8	0.6	0.1	0+	0+						2.2
total	5.4	13.9	18.8	26.6	25.9	6.8	2.2	0.3	0+	0+	0+	0+		

total number of observations = 262968 the entry "0+" indicates the percentage is between zero and 0.05

STATION NAME: CLAREMORRIS

RP5 60min= 15.6 MM : RP5 2d=55.3 MM : ANNUAL RAINFALL = 1143

RAINFALL IN MM. FOR A RANGE OF DURATION AND RETURN PERIOD

	RETURN PERIOD (YEARS)						
DURATION	1/2	1	2	5	10	20	50
15 min	4.7	5.9	6.6	9.0	10.9	13.1	16.6
30 min	6.3	7.9	8.8	11.9	14.6	17.4	22.1
60 min	8.4	10.5	11.7	15.6	18.7	22.3	27.9
2 hr	11.3	13.9	15.3	19.9	23.5	27.5	33.4
4 hr	15.3	18.5	20.3	26.0	30.4	35.1	42.4
6 hr	18.9	22.6	24.5	31.0	35.9	40.9	48.9
12 hr	24.0	28.7	31.0	39.3	45.5	51.8	62.0
24 hr	30.3	35.6	39.0	48.1	54.8	62.5	73.1
48 hr	36.9	43.4	47.5	58.6	66.8	76.2	89.1

CLAREMORRIS

monthly and annual mean and extreme values
1961-1990

lat 53° 42' N
long. 8° 59' W
height 71 metres above mean sea level

TEMPERATURE *(degrees Celsius)*	*jan*	*feb*	*mar*	*apr*	*may*	*jun*	*jul*	*aug*	*sep*	*oct*	*nov*	*dec*	*year*
mean daily max.	7.2	7.6	9.6	12.0	14.5	17.0	18.4	18.2	16.1	13.2	9.5	7.9	**12.6**
mean daily min.	1.4	1.3	2.3	3.3	5.5	8.2	10.2	9.8	8.1	6.3	3.0	2.3	**5.1**
mean	4.3	4.5	5.9	7.6	10.0	12.6	14.3	14.0	12.1	9.8	6.2	5.1	**8.9**
absolute max.	13.1	13.3	20.1	22.3	25.1	29.8	30.5	27.2	23.3	19.9	15.4	14.3	**30.5**
absolute min.	-11.7	-17.1	-8.0	-5.5	-3.1	-0.4	0.6	1.1	-1.2	-4.0	-5.3	-8.3	**-17.1**
mean no. of days with air frost	9.7	8.9	6.8	3.9	0.8	0.0	0.0	0.0	0.0	1.1	6.1	8.3	**45.6**
mean no. of days with ground frost	16.0	14.9	13.2	11.5	5.9	1.0	0.2	0.3	2.0	4.4	13.1	14.5	**97.0**
RELATIVE HUMIDITY *(%)*													
mean at 0900UTC	91	91	88	84	80	81	84	87	89	92	92	92	**88**
mean at 1500UTC	86	79	74	69	68	72	73	75	77	81	85	88	**77**
SUNSHINE *(hours)*													
mean daily duration	1.45	2.11	2.87	4.40	5.08	4.64	3.79	3.81	3.10	2.39	1.81	1.11	**3.05**
greatest daily duration	7.8	9.2	11.7	13.7	15.1	15.6	14.8	13.7	12.3	10.1	8.6	7.0	**15.6**
mean no. of days with no sun	11	8	6	3	2	2	3	3	4	6	9	12	**69**
RAINFALL *(mm)*													
mean monthly total	120.8	83.2	95.5	62.3	77.9	71.[illegible]	63.8	96.6	104.3	124.6	118.8	124.1	**1143.2**
greatest daily total	33.1	27.9	27.5	19.8	42.0	74.6	38.8	55.0	41.6	59.5	49.2	41.0	**74.6**
mean no. of days with >= 0.2mm	22	17	21	17	18	16	17	19	19	22	21	22	**230**
mean no. of days with >= 1.0mm	18	14	17	12	14	12	11	14	15	17	17	17	**178**
mean no. of days with >= 5.0mm	9	6	7	4	6	4	4	6	7	8	8	8	**78**
WIND *(knots)*													
mean monthly speed	10.0	10.0	10.2	8.7	8.3	7.9	7.5	7.3	8.0	9.0	8.7	9.7	**8.8**
max. gust	96	85	74	57	62	54	66	54	91	70	70	79	**96**
max. mean 10-minute speed	59	48	45	36	41	36	39	33	60	46	40	51	**60**
mean no. of days with gales	1.2	0.9	1.0	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.5	0.7	**5.2**
WEATHER *(mean no. of days with...)*													
snow or sleet	6.5	5.4	4.7	1.9	0.3	0.0	0.0	0.0	0.0	0.1	1.7	3.5	**24.1**
snow lying at 0900UTC	2.6	1.4	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	**6.3**
hail	4.2	3.3	5.7	3.6	1.9	0.4	0.0	0.0	0.7	1.0	3.0	2.7	**26.5**
thunder	0.4	0.2	0.2	0.3	0.5	0.9	0.9	0.4	0.2	0.4	0.3	0.5	**5.1**
fog	4.4	2.7	1.9	2.4	1.7	2.3	2.3	4.1	4.1	4.6	3.6	3.7	**37.9**

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O'Callaghan Moran & Associates
ENVIRONMENTAL MANAGEMENT FOR BUSINESS

LANDFILL GAS ADDENDUM

to

UPDATED TIER 2 AND TIER 3

ENVIRONMENTAL RISK ASSESSMENT

OF A

FORMER MUNICIPAL LANDFILL

CASTLEREA,

COUNTY ROSCOMMON

This addendum was prepared to address Item 4 of the Further Information request from the Environmental Protection Agency in relation to the certification of Castlerea Landfill.

1.1 Landfill Gas

Ground gas monitoring was undertaken on three occasions; on the 1st December 2017, on 8th August 2019 and following a request from the EPA in February 2020 on March 24th 2020. The monitoring included the measurement of methane, carbon dioxide, oxygen and atmospheric pressure and gas flow rate using a Gas Data LSMx gas analyser. The meter was calibrated before use. The detection limit is 0.1% for methane, carbon dioxide and oxygen. Only the groundwater wells were monitored during the August 2019 monitoring round but all of the wells were monitored in March 2020.

It had not been possible to open the well cover of the leachate well in 2019 due to corrosion of the locking bolts, therefore no landfill gas monitoring was undertaken on this well at that time. The well cover was opened in 2020. The results are presented in Table 1

The results indicate that landfill gas is being generated. The 2017 monitoring results for MW-1 to the south of the landfill may be an indication of methane build up associated with peaty soil south of the landfill. The well is only open to the formation in the gravels at least 7-10m below ground level therefore the origin of the methane is not considered to be the landfill. Methane was not detected in the 2019 monitoring programme in this well and is at very low levels in 2020.
It is possible however that the levels detected in MW-2 to the north are associated with the presence of waste at this location, but again it is primarily considered to be naturally occurring given the well is also screened at least 3-4 m below the level of the waste in saturated conditions. It is possible that the methane could originate from the peat subsoil locally. There was no gas flow in the MW-1 or MW-2 in 2019 indicating the landfill gas migration is relatively low at this locations. Methane and carbon dioxide levels remain low in MW-2 during the 2020 monitoring period.

As outlined in the 2019 updated report it is likely that the landfill gas in the landfill is migrating laterally towards the surface water drains.

Four gas ventilation wells should be installed, two in area A1 and two in Area A2 to allow passive ventilation of the gas. The well pipes should be 100mm slotted uPVC and should extend 150mm above the top soil layer. These wells should be fitted with cowls to prevent damage by livestock.

The landfill gas risk to off site receptors is considered to be low and the remedial measures proposed will mitigate the residual risk.

Table 1 Landfill Gas Data – December 2017, August 2019, and March 2020

		Atmospheric Pressure	Flow rate	CH_4 (Peak)	CO_2	O_2
Location	Date / Unit	mb	l/h	%	%	%
L1	01/12/2017 - 12.30 pm	1018	29.10	76.00	24.00	0.00
MW1	01/12/2017 - 12.30 pm	1018	0.10	3.70	19.00	15.20
MW2	01/12/2017 - 12.30 pm	1018	0.00	0.50	1.80	21.00
		Atmospheric Pressure	Flow rate	CH_4 (Peak)	CO_2	O_2
Location	Date / Unit	mb	l/h	%	%	%
MW1	8th Aug 2019 - 11.00 am	1001	0.00	0.00	10.00	12.60
MW2	8th Aug 2019 - 11.00 am	1002	0.00	1.80	5.20	15.70
		Atmospheric Pressure	Flow rate	CH_4 (Peak)	CO_2	O_2
Location	Date / Unit	mb	l/h	%	%	%
L1	24/03/2020	1006	1.3	75.60	27.70	0.10
MW-1	24/03/2020	1006	0.8	0.1	0.1	20.9
MW-2	24/03/20	1006	0.7	0.9	0.6	20.2