EAST CORK LANDFILL
ROSSMORE
CARRIGTOHILL
CO CORK

ENVIRONMENTAL PROTECTION AGENCY

WASTE LICENCE W0022-01

ANNUAL ENVIRONMENTAL REPORT

1st JANUARY - 31st DECEMBER 2008

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1 Introduction

1.1 Scope and Purpose of the Annual Environmental Report

Cork County Council holds an E.P.A. Waste Licence W0022-01 to operate waste disposal activities at East Cork Landfill, Rossmore, Carrigtohill. The aim of the Annual Environmental Report is to provide a review of activities at Rossmore within the last twelve months. The Table of Contents is derived from Schedule C of the Waste Licence.

1.2 Background to the Report

The landfill facility has been in operation at Rossmore since 1986 with waste received in the lined cells since 10th January 1995. The Waste Licence was issued to Cork County Council by the E.P.A. on 27th July 2000.

In accordance with Condition 2.8 of Waste Licence 22-1 an Annual Environmental Report will issue from the site to the Agency.

This is the eight A.E.R. for the landfill and covers the period 1st January to 31st December 2008.

1.3 Site Location

The facility is located 2½ km south of the N25 at Carrigtohill in the townland of Rossmore.

The site address is:

East Cork Landfill
Rossmore
Carrigtohill
Co. Cork

Tel. (021) 4533934
Fax. (021) 4533880
e-mail: jerome.obrien@corkcoco.ie

1.4 Environmental Policy

Cork County Council is committed to conducting all activities such that they have a minimal effect on the environment. The main objectives are:

A commitment to comply with the Conditions of the Waste Licence and all relevant environmental legislation.

To ensure that management and all personnel working on the site are familiar with the Conditions of the Waste Licence, the content of the Environmental Management Plan and the Emergency Response Procedures.

2 SITE DESCRIPTION AND ACTIVITIES

2.1 Description of the Site

East Cork Landfill is sited in the Rossmore Peninsula at the midpoint of the northern estuary of Cork Harbour, 10 km from Midleton, 19 km from Cork City and 5 km from the industrial area of Little Island.

The site is the void left by limestone quarrying formerly owned and worked by Readymix (now Cemex) Ltd. The total site occupies an area of 38 acres of land. The mining resources are depleted since December 2001

The former waste disposal floor area of the site occupies 16.25 acres.

The peninsula has grazing and tillage farming activities almost completely on the perimeter of the landfill. A former oyster farming business, owned by Atlantic Shellfish Ltd., also shares the south-eastern end of the region.

Cork Harbour waters almost fully surround the peninsula and there are extensive mudflats at low tide which provide feeding grounds for aquatic birds. The baseline ecological study indicated a quality of invertebrates, annelids and crustaceans not normally associated with waters adjacent to a landfill.

This region of Cork Harbour is a designated Special Protection Area for wildlife.

There is one groundwater abstraction in the peninsula which is included in the monthly schedule of monitoring. Potable water is supplied to the locality by a Cork County Council main.

The prevailing wind directions over the site are varied but predominantly south-western. The change in tides has an effect on wind speed and impacts on site.

The access road from the nearest Local route is in private ownership. It is not possible to place traffic calming, control signage or direction signage along this route as it is ‘not in charge’. The surface is maintained and cleaned by Cork County Council under Condition 4.4.2. Following the construction of an asphalt plant by Irish Asphalt Ltd the road was widened in accordance with planning requirements.

2.2 Reporting Period

The period being reported on is that from 1st January to 31st December 2008.

2.3 Waste Activities now carried out at the Facility

Waste activities at East Cork Landfill are restricted to those outlined in Schedule A of the Waste Licence in accordance with the Waste Management Act: Third Schedule, as outlined below.

Class 4: Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons.

Class 7: Physico-chemical treatment not referred to elsewhere in this Schedule (including evaporation, drying, and calcination) which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule.

Class 11: Blending or mixture prior to submission to any activity referred to in a preceding paragraph of this Schedule.

Class 12: Repackaging prior to submission to any activity referred to in a preceding paragraph of this Schedule.

Class 13: Storage prior to submission to any activity referred to in a preceding paragraph of this Schedule other than temporary storage, pending collection, on the premises where the waste concerned is produced.

2.4 Quantity and Composition of Waste Received and Disposed

The quantity and composition of waste received, disposed of, recovered and recycled during the reporting period is outlined in Table 2.1.

Table 2.1: Quantities of MS Waste Received at Civic Amenity and Disposed of at landfill during the Reporting Period

Month	Quantity of Waste / tonnes	Disposal Destination
January 2008	**148.86**	Youghal Landfill
February	**115.53**	Youghal Landfill
Total	**121.01**	Youghal Landfill
March	**142.14**	Youghal Landfill
April	**113.78**	Youghal Landfill
May	**121.91**	Youghal Landfill
June	**121.91**	Youghal Landfill
July	**160.50**	Youghal Landfill
August	**136.37**	Youghal Landfill
September	**145.45**	Youghal Landfill
October	**79.86**	Youghal Landfill
November	**144.28**	Youghal Landfill
December	**127.85**	Youghal Landfill
Total	**1,557.54**	

Table 2.2: Quantities of C&D Received and Disposed of during the Reporting Period

Month	Quantity of C&D/tonnes	Disposal Destination
none	none	none

The software associated with the weighing mechanism is constantly under review by Precia Molen Ltd., maintenance contractors to Cork County Council. Annual weighbridge calibration is performed by Precia Molen Ltd under new metrology Regulations and the calibration certificate is held in the site file.

2.5 Tank Testing and Inspection Reports

Leachate integrity testing, inspection and certification was carried out on both of the leachate lagoons. This was performed by Geomembrane Testing Services Ltd. to comply with Condition 4.14.5 of the Waste Licence.

3 Summary of Monitoring and Emissions

3.1 Landfill Gas

The possible migration of landfill gas is monitored by site technical staff in accordance with the frequencies indicated in Schedule F, Table F.1 (a) and Condition 9 of the Waste Licence. The offsite movement of landfill gas is detected by monitoring the boreholes situated around the perimeter of the site. Constant landfill gas monitoring is taken in the accommodation areas including the site office, weighbridge and material store to detect the accumulation of methane and carbon dioxide. Monitoring is performed on the wells located on the capped landfill.

The landfill gas detection device is a LMSx Multigas Analyzer, calibrated annually by Alpha Technologies Ltd.

FTC Drawing No.2000-004-18-10 Rev 'E' is the illustrated layout of the landfill gas monitoring locations agreed with the Agency.

The installation of the Landfill Gas Flare in September 2004 has resulted in constant flaring of emissions. The recorded results were sent to the Agency as part of the monthly monitoring. The average percentage for methane, oxygen and carbon dioxide gas burned on the site is in the region of 30 - 40%, 1-3% and 30-33% respectively. Gas field balancing is carried out on site when required. The gas is collected from 27 wells in the lined area of the landfill and 8 wells in the unlined area of the landfill. The gas main was extend to incorporate cells 6 to 8b and transducer risers at cells 8b to 9 and also the pump risers at cells 9 and 10 in a bid to reduce odour nuisances in these areas. The results are relayed to a PC in the main office building.

Average levels for methane, oxygen and carbon dioxide burned at the flare are 38, 1 and 33% respectively with gas field-balancing been done when required. This indicates that the site is capable of generating commercial quantities of electricity which can feed into the aerial conductor system crossing the site.

3.2 Surface Water

Surface water is monitored at the locations described in Schedule F, Table F4.2, of the Waste Licence and FTC Drawing No.2000-004-18-10 Rev 'E' by agreement with the Agency and in accordance with Condition 9. The frequency and composition of analysis is illustrated in Table F4.2 of the Licence. Consultants RPS MCO'S Ltd. Sample, analyse and interpret the results of the surface water monitoring on behalf of Cork County Council.

Precipitation falling on the capped landfill is directed by gravity to the surface water lagoon. Some falls to the new holding tanks to the rear of Lagoon 2 from where it is pumped to the surface water lagoon at the western end of the site. There, sampling takes place before the inlet and at the outlet for TOC, pH and conductivity.

Installed by Automatic Flare Systems Ltd., the flow is continuously sampled and results compared and trigger levels set. If these levels are exceeded in any of the above an actuated valve closes the outlet pending an investigation of the cause of the exceedence.

3.3 Groundwater

Surface water is monitored at the locations described in Schedule F5 of the Waste Licence and FTC Drawing No.2000-004-18-10 Rev 'E' by agreement with the Agency and in accordance with Condition 9. The frequency and composition of analysis is illustrated in Table F4.2 of the Licence. Requiring that some parameters are monitored monthly, some quarterly and others annually. Consultants RPS MCO'S Ltd. sample, analyse and interpret the results of Groundwater monitoring on behalf of Cork County Council.

3.4 Leachate

Leachate is monitored at the locations described in Schedule F.6, Table F6.1, of the Waste Licence and FTC Drawing No.2000-004-18-10 Rev 'E' by agreement with the Agency and in accordance with Condition 9. The frequency and composition of analysis is illustrated in Table F4.2 of the Licence.

Leachate levels in the ten waste cells and both lagoons are recorded daily on the instruction of the Agency. pH and temperature readings are recorded daily also as per Table F7.1.

Leachate analysis for ammonia, suspended solids, BOD and COD is conducted weekly at Inniscarra Laboratories on leachate samples from the lagoons.

Ammonia levels have shown an overall range is from 450 to 2200mg/l in Lagoon 1 and from 560 to 2500mg/l in Lagoon 2 in the monitoring period. pH has shown no major change in comparison to the last reporting period, with ranges from 7.32 to 8.60 in Lagoon 1 and from 7.34 to 8.60 in Lagoon 2 which is the main leachate collector.

BOD values range from 36 to 140mg/l for Lagoon 1 and from 36 to 142mg/l for Lagoon 2 over the period. COD varies from 660 to 2250mg/l for Lagoon 1 and from 400 to 2130mg/l for Lagoon 2. The ranges are substantially lower than results recorded in 2007.

3.5 Noise

A noise survey was carried at the landfill in accordance with the requirements of Schedule F.3 and Table F.3, Schedule G1 on the 21st of July and the 29th August, the locations illustrated in FTC Drawing No.2000-004-18-10 Rev 'E' and Condition 9.3. All locations were within the limits as set out in the Waste Licence. The results indicate that the maximum equivalent continuous noise measurement was 53dBA at monitoring locations N4 opposite the site entrance gate. The second highest measurement of 47 dBA is located at GG1 located at the north-western end of the site and N5 at the western boundary of the landfill. The third highest measurement was 45 dBA at monitoring location N3, this monitoring point is situated on the lane to Atlantic Shellfish Ltd. All other recordings were lower than these and again within the limit of 55dBA as directed by Schedule G2 of the Waste Licence. Results for 2008 are indicative of the decline in activity and are the lowest since records first begun in 2000. The report by the Environment Department, Cork County Council, is contained in Attachment F.

3.6 Dust

Three dust surveys were carried in accordance with the requirements of Schedule F.3 and Table F.3, Schedule G2, the locations illustrated in FTC Drawing No.2000-004-18-10 Rev 'E' and Condition 9.5. The dust was collected in Bergerhoff bottles of aperture size from 88mm diameter.

The dust limit in Schedule G2 of 350mg/m^2/day was slightly exceeded in locations D3 and D4 during the three monitoring periods. In the case of D3 this is as a result of concrete blocks been delivered in this area for the capping works and causing a cloud of dust to rise. In the case of D4 this may have been as a result of proper procedures not been followed such as washing out of the gauges before or during the erecting of the sampling gauges due to the presence of algae, flies and bees in the sampling bottle thereby adding to the net weight of the samples. Tampering of all four gauges cannot be ignored as on one occasion during sampling the bergerhoff gauges and bottles were taken from the site.

3.7 Dust Survey

Table 3.1

Date	Location	Duration	Dust Concentration	Dust Level mg/m^2/day
August 08	Atlantic Shellfish D1	30 days	3.9mg	21.37
	Civic Amenity D2	30 days	5.3mg	29.04
	South Road (pylon) D3	30 days	135.9mg	744.83
	North-western corner D4	30 days	24.4mg	133.73

Date	Location	Duration	Dust Concentration	Dust Level mg/m^2/day
October 08	Atlantic Shellfish D1	30 days	0.1 mg	0.55
	Civic Amenity D2	30 days	5.4 mg	29.6
	South Road (pylon) D3	30 days	61 mg	35.07
	North-western corner D4	30 days	9.7 mg	53.16

Date	Location	Duration	Dust Concentration	Dust Leve mg/m^2/day
December 08	Atlantic Shellfish D1	30 days	1.30mg	7.12
	Civic Amenity D2	30 days	17.10mg	93.71
	South Road (pylon) D3	30 days	2.40mg	13.15
	North-western corner D4	30 days	69.500mg	380.90

3.8 Ecology Parameters

This licence period the ecology monitoring of the landfill surrounds was placed for tender and Limosa Environmental was the successful tenderer. Dr Lesley Lewis has conducted an extensive ecology report on this site in accordance with the agreed parameters set out by the Agency in Condition 9.14.

The annual ecology survey is enclosed as Attachment G, and includes as required the following:

- *Brief survey of terrestrial component of site to assess changes in habitats and species of flora and fauna since baseline survey of 1998.*

- *Survey of estuarine sediments and shoreline for macro-invertebrates, macro, algae and Spartina distribution.*

- *Analysis of sediments (collected from same sampling points as for fauna/flora) for total nitrogen, total phosphorus, copper, cadmium chromium, zinc, lead and mercury. Organic content of sediment would also be determined. Results to be compared with 1998 data.*

- *Interpretation of water quality data for North Channel area from water quality programme as carried out by Environmental Protection Agency.*

- *Assessment of usage of intertidal flats by feeding wildfowl and waders in vicinity of Rossmore Peninsula and Brick Island. This would be done by systematic observations during low tide periods. Up to six visits would be made during the winter period.*

- *Assessment of relative importance of the North Channel area within the Cork Harbour SPA. This would be done by analysis of data for Cork Harbour from the I-WeBS scheme.*

- *Summary and interpretation of the significance of results of monitoring of shellfish growing areas in the vicinity of the landfill as undertaken by the Department of the Marine and Natural Resources.*

- *Contact with Duchas re any recent surveys or monitoring that might have been carried out in the SPA and the proposed NHA and also to discuss the possible trends in bird population.*

4 Site Development Works

4.1 Site Development Works during Reporting Period

Site development works during the reporting period include licensed activities perceived as proper closure of the landfill.

The areas of development and installation to date in this licence year consist of:

(i) Excavation and laying of gas collection pipework, knockout pots and manifolds.

(ii) Installation of leachate re-circulation pump from Lagoon 1 to Cells 4^{+}-10 and automated control valves to each leachate feed tank. Power is provided by solar energy.

(iii) Connection of SCADA control to a PC in the landfill office for each of the above.

The works were designed by Fehily Timoney & Co, Environmental Consultants. Supervision was provided by site staff. The works contractors for the above projects were Automatic Flare Systems Ltd., Unit 18, Ensign Business Park, Coventry, West Midlands, U.K and Lining Technology Ltd., Unit 1A, Airport Business Park, Waterford.

4.2 Proposed Development Works

Cork County Council proposes the following site development works and completion of existing works in the coming year, January-December 2009 pending expressions of interest, design, tendering and appointment of competent contractor/s:

i) Utilization of landfill gas as an energy resource.

4.3 Site Development Works during the coming Year

The site development works for the current Waste Licence year will be as 4.2, Proposed Development Works *i.e.* works incomplete in 2008 contract.

4.4 Report on completed Development Works

The only works of significance which ran in 2008 were the continuation of capping of the remaining waste cells 4^{+}-10. The works were designed in accordance with the requirements of the Waste Licence but incorporate synthetic liners which will out-perform the requisite mineral layers specified. Leachate production and gas emissions are eliminated to significantly reduce Ireland's contribution to GHG emissions.

4.5 Site Survey

The most recent site survey of the landfill topography was taken on January 22nd 2008. The contemporary topographical survey by Focus Surveys Ltd, Drawing no. 00-023_1 Rev ZJ, is enclosed as Appendix E.

4.6 Slope Stability

Analysis of slope stability in accordance with Condition 9.20 on a selected area of the restored cells was carried out by Fehily Timoney & Co. The analysis was conducted using the *Reslope* software programme on twelve locations. Factors of safety ranging from 1.25 to 2.23 evolved indicating stable conditions. A full and comprehensive report is included in Appendix A.

4.7 Quantity of Indirect Emissions to Goundwater

There are no indirect emissions from the site to groundwater. The cell leachate level condition is complied with as much as is possible given volumetric constraints at the waste water treatment plant. Monitoring of surface water does not indicate contamination from leachate.

4.8 Water Balance Calculations

The water balance calculations are illustrated in Appendix B. The volume of leachate predicted is 1,494m^3 less than tankered off for that Licence period. The significance of this deficit can be attributed to lesser absorptive properties of the waste than assumed, high levels of moisture retention in sludges and low levels of evapo-transpiration during the year.

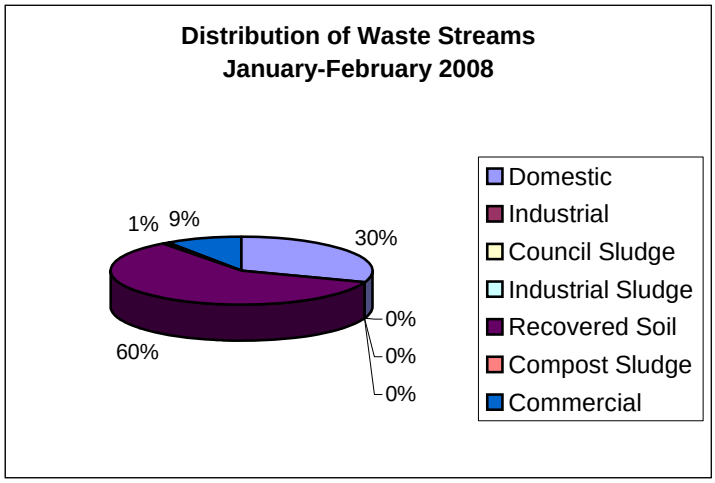
5 Wastewater Received by the Facility

5.1 Waste Acceptance

Only domestic MSW in small quantities are accepted at the facility in ro-ro bins for collection, transport and disposal at East Cork Landfill

The site offers a comprehensive range of vessels for the storage of solid and liquid recyclable materials.

The site generates approximately 4 tonnes of WEEE each week



EAST CORK LANDFILL WASTE INTAKE RECORDS						2008							
Waste Type	**Jan.**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Cum. Total**
Total of Waste sent to Youghal L/F from CA Site (MSW)	**148.86**	**115.53**	**121.01**	**142.14**	**113.78**	**121.91**	**160.50**	**136.37**	**145.45**	**79.86**	**144.28**	**127.85**	**1,557.54**
Recycling													
Bottle Banks and can recycling	7.58	2.74	5.70	10.74	0.20	5.24	3.92	3.84	4.49	3.38	5.96	3.93	**57.72**
Metals	12.93	8.68	10.20	4.58	13.00	9.60	16.54	8.52	8.86	6.38	14.66	10.88	**124.83**
Timber	18.83	18.88	19.20	14.12	23.68	22.44	23.46	40.62	17.80	8.5	30.64	17.7	**255.87**
Cardboard	9.08	7.64	10.92	4.54	6.02	10.60	9.59	5.08	7.80	7.8	7.4	13.18	**99.65**
Newspapers & card	14.06	9.75	13.87	12.62	9.42	10.62	13.22	7.34	11.82	10.01	11.78	11.74	**136.25**
Batteries				0.30			0.50				2.22		**3.02**
Fluorescent tubes/ lamps		0.20										0.06	**0.26**
Plate Glass		5.18			4.54	7.24				6.84			**23.80**
Plastics	2.35	2.92	1.41	7.89	1.83	2.10	1.89	1.96	1.49	1.84	1.8	1.78	**29.26**
WEEE (all white goods)	16.12	26.04	5.34	12.99	14.86	21.04	23.42	16.28	20.11	24.98	21.74	15.22	**218.14**
Cooking Oil				2.80									**2.80**
Engine Oil	1.50	0.62			0.72	0.62	0.74		1.72	0.96	0.4		**7.28**
Farm Plastics													-
Paints		0.36			0.33	0.74	0.34		0.37	0.29		0.5	**2.93**
Total Recycled	**82.45**	**83.01**	**66.64**	**70.58**	**74.60**	**90.24**	**93.62**	**83.64**	**74.46**	**70.98**	**96.6**	**74.99**	**961.81**

6 ENVIRONMENTAL INCIDENTS AND COMPLAINTS

6.1 Incidents

The following is a table of reportable incidents under Condition 3.1 which occurred this Licence period. It also outlines corrective action, if any required, taken by site management to prevent recurrence.

Site Incidents Log

Date	Nature of Incident	Cause	Corrective Action
15/01/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
18/02/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
13/03/08	LFG flare shut down	Accidental depression of emergency shut off switch	Restart flare following maintenance of ignition rod
14/03/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
15/03/08	LFG flare shut down	ESB power failure	Restart LFG flare on arrival to site
16/04/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
17/04/08	LFG flare shut down	Mechanical failure of venting louvres	Reset power, turn to manual

Date	Nature of Incident	Cause	Corrective Action
23/05/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
17/06/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
17/07/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
28/07/08	LFG flare shut down	Electronic control and signals to office pc lost	Blown fuse causing outage of many LFG functions replaced
16/08/08	LFG flare shut down	ESB power failure due to lightning strike	Restart LFG flare on arrival to site
21/08/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.

Date	Nature of Incident	Cause	Corrective Action
22/09/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
28/10/09	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
19/11/05	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.
23/12/08	Lf Gas: exceedance of limits set out by the waste licence	Boreholes recently re-drilled and development works are ongoing on site leading to the area becoming unsettled. It also may be naturally occurring within this area.	To allow boreholes to settle and await the completion of the capping works on site.

Table 6.1

6.2 Complaints

There were no complaints registered against the site this year.

Site Complaints Log

Date	Complainant	Cause	Corrective Action	CAR Ref Number

Table 6.2

7 ENVIRONMENTAL MONITORING

7.1 Summary and Interpretation of Environmental Monitoring Results

DOCUMENT CONTROL SHEET

Client	Cork County Council					
Project Title	Rossmore Landfill					
Document Title	Annual Environmental Report 2008					
Document No.	RPS/033033001RP0067F01					
This Document Comprises	DCS	TOC	Text	List of Tables	List of Figures	No. of Appendices
	1	1	14	0	0	0

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
F01	Final Issue	N. Noonan			Cork	January 2009

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REVIEW OF MONITORING DATA AT ROSSMORE LANDFILL JANUARY TO DECEMBER 2008

INTRODUCTION

A comparison has been made with the environmental monitoring results for monitoring period January to December 2008 and the 2006 and 2007 monitoring data to establish if any changing trends in the composition of the leachate, groundwater or surface water are apparent.

SURFACE WATER MONITORING

Surface water quality monitoring has been undertaken at three locations (SW1, SW2, SW3) in the vicinity of Rossmore Landfill. Quarterly monitoring is undertaken of the ammoniacal nitrogen, BOD, COD, chloride, dissolved oxygen, electrical conductivity, pH, total suspended solids and temperature. The results of the surface water monitoring at Rossmore Landfill during 2008 have been compared to the results of monitoring in 2006 and 2007.

During the monitoring period, quarterly monitoring was undertaken in February, May, August and November 2008. A more comprehensive analysis is required by the EPA on an annual basis and this was undertaken on the November 2008 round of sampling. In all of the monitoring undertaken to date the results indicate the surface water composition is most strongly influenced by its estuarine locations as reflected in the naturally high electrical conductivity and chloride concentration.

pH

The pH monitoring data indicates that the pH ranges from 7.07 to 8.23 pH units during the monitoring period. When compared to the previous two years monitoring data (2006 & 2007) there has been no significant change in the range of values measured. The pH data is summarised in Table 1.

Table 1: Surface Water pH (pH Units)

Monitoring Location	Minimum (2008)	Maximum (2008)	Average (2008)	Range (2007)
SW1	7.07	8.23	7.73	7.23-8.06
SW2	7.35	8.17	7.86	7.20-8.33
SW3	7.17	7.86	7.66	7.01-8.17

Electrical Conductivity

The electrical conductivity at the surface water monitoring locations ranged from 31,330 to 46,200 us/cm during 2008. This range is within than the ranges seen in 2006 and 2007. The electrical conductivity is highly influenced by the estuarine location of the monitoring points which gives rise to a naturally elevated electrical conductivity.

Table 2: Surface Water – Electrical Conductivity (uS/cm)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	31,100	44,900	38,275	26,300-57,900
SW2	35,700	46,200	41,050	35,500-58,700
SW3	33,300	44,300	37,150	34,500-58,200

Ammonical Nitrogen

The 2008 results indicate a range in ammoniacal nitrogen from <0.01 to 0.27 mg/l. The maximum levels during 2008 are lower than the maximum levels seen during 2006 and 2007 at SW1 and SW2. Ammoniacal nitrogen levels during 2008 were lower than 2006 levels at SW3.

Table 3: Ammonical Nitrogen (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	0.02	0.25	0.1375	<0.01-0.32
SW2	<0.01	0.04	0.04	<0.01-0.07
SW3	0.02	0.27	0.1225	<0.01-0.13

Dissolved Oxygen

The dissolved oxygen levels ranged from 92% to 100%. This range is an improvement on the range seen in 2006 and 2007.

Table 4: Surface Water – Dissolved Oxygen (% Saturation)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	97	100	98.65	69.2-93
SW2	97.9	100	98.9	61.4-97.5
SW3	92	100	96.1	70.7-92.1

Chloride

The results of the chloride monitoring are summarised in Table 5. The concentration ranged from 10,143 to 24,762mg/l in 2008. This is within the range seen in 2007. There are normally significant variations in the chloride concentration at this site due to the estuarine nature of the monitoring locations.

Table 5: Surface Water (Chloride mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	10,143	21,321	15,275	13,761-26,683
SW2	10,194	24,602	17,399	16,770-28,667
SW3	17,657	24,762	21,065.75	21,304-26,905

Chemical Oxygen Demand

The COD levels at the surface water monitoring locations ranged from 50 to 460 mg/l in 2008. The COD levels in 2008 are above recently seen ranges. However, higher levels were recorded in 2004. The results are summarised in Table 6.

Table 6: Surface Water – Chemical Oxygen Demand (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	140	340	252.5	20-150
SW2	50	460	247.5	120-200
SW3	192	400	288	60-230

Biochemical Oxygen Demand

During 2008 the BOD levels ranged from 1mg/l to 74mg/l. The levels exceed previously detected levels.

Table 7: Surface Water – Biochemical Oxygen Demand (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	1	74	32.75	<1-3
SW2	1	55	19	<1-33
SW3	1	65	32.25	<1-3

Suspended Solids

The concentration of suspended solids ranged from 116 to 915 mg/l during 2008. The levels at SW3 are slightly above the range seen in 2007. The SW3 range is lower than the range recorded in 2005.

Table 8: Surface Water – Suspended Solids (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
SW1	185.5	915	265.375	85.3-915
SW2	116	316	186	23.3-638
SW3	183	396	257	65.5-386

ANNUAL SURFACE WATER PARAMETERS

The results have been compared to the 2006 and 2007 monitoring data for the site and to the environmental quality standards (EQS) set for surface water by the EPA in the publication "Towards Setting Guideline Values for The protection of Groundwater in Ireland". With the exception of an increase in lead, the results of the monitoring of the annual parameters in 2008 indicate similar levels to those seen in 2006 and 2007.

SWI

Analysis of the annual parameters indicates a similar composition to that seen previously. Most of the parameters are within the EQS levels set for surface water. There has been a decrease in the concentration of nitrate to 3.6mg/l from 42.1 mg/l in 2007 and 39.19mg/l in 2006. There has been a reduction in the calcium, copper, iron, manganese, nitrate, potassium, sulphate, total alkalinity and TON concentrations from the 2006 and 2007 levels. The levels, with the exception of sulphate and calcium, are less than the EQS for surface water. There has been an increase in the concentration of chromium, magnesium, lead, sodium and total phosphorous levels from 2007. However with the exception of total phosphorous levels are within previously detected ranges. Sulphate concentrations vary significantly due to the tidal conditions; this has been seen on all sampling occasions to date.

The remainder of the annual parameters are within the normal range seen previously. It should be noted that the surface water in the vicinity of the site is not suitable for drinking water purposes due to the proximity of the site to the estuary.

Table 9: SWI Annual Results

Parameter	Annual Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	379	218.5	478.5	398.9	358.8
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	<0.0035	<0.0035
Total Chromium Cr	0.068	< 0.01	<0.01	<0.01	0.014
Copper Cu	0.31	< 0.015	0.017	0.013	< 0.015
Iron Fe	0.626	0.476	0.254	0.183	0.087
Lead Pb	< 0.049	0.098	<0.049	<0.049	0.046
Magnesium Mg	565	766.5	1,246	710.6	866.6
Manganese Mn	0.259	0.026	0.019	0.078	0.017
Mercury Hg	< 0.0005	0.0005	<0.0005	<0.0005	<0.0005
Potassium K	180	225.9	430	350.1	314.3
Sodium Na	1,110	5,772	9,922	5,748	6,288
Sulphate SO_4	1,807	1458.1	1726	2344	227.5
Zinc Zn	0.114	< 0.011	<0.011	<0.011	<0.011
Total alkalinity (as $CaCO_3$)	117	115	177	149	129
Total oxidised nitrogen TON	< 0.1	0.85	8.82	9.47	0.81
Nitrite NO_2	< 0.1	0.18	<0.05	<0.05	<0.05
Nitrate NO_3	< 0.1	3.52	39.19	42.1	3.6
Total Phosphorous P	< 0.01	0.04	0.05	0.05	0.25

SW2

Analysis of the annual parameters indicates similar results to those seen previously at the site. The majority of the parameters are within the EQS for surface water. The total oxidised nitrogen concentration decreased to 1.01mg/l in 2008 compared to 10.01 mg/l in 2007. The nitrate concentration has decreased to 4.5mg/l from 44.9mg/l in 2007 lower than the EQS for surface water. Sulphate decreased from 2,527mg/l in 2007 to 345.5mg/l in 2008. The concentration of sodium increased in 2008 to 9,231mg/l exceeding previously detected levels. There have been slight increases in the concentrations of cadmium, calcium and lead in comparison to previously detected levels. The copper, iron, manganese, mercury and sulphate concentrations are below levels detected in 2007. The remainder of the annual parameters are within the normal range seen previously.

Table 10: SW2 - Annual Results

Parameter	Annual Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	414	361.4	413.3	346.3	432.3
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	<0.0035	0.009
Total Chromium Cr	0.069	< 0.01	<0.01	<0.01	0.014
Copper Cu	0.385	< 0.015	<0.015	0.016	<0.015
Iron Fe	0.62	< 0.03	1.392	0.163	< 0.03
Lead Pb	< 0.049	< 0.002	0.006	<0.049	0.035
Magnesium Mg	597	1078	1288	935.2	1068
Manganese Mn	0.415	< 0.014	0.058	0.074	< 0.014
Mercury Hg	< 0.0005	< 0.0005	0.0008	<0.0005	< 0.0005
Potassium K	397	316.5	360.3	292.2	396.9
Sodium Na	6,380	8,763	3,648	6,035	9,231
Sulphate SO_4	3,576	1,417	1,523	2,527	345.5
Zinc Zn	0.265	< 0.011	<0.011	<0.011	<0.011
Total alkalinity (as $CaCO_3$)	112	116	121	164	116
Total oxidised nitrogen TON	< 0.1	0.81	1.14	10.1	1.01
Nitrite NO_2	< 0.1	0.08	<0.05	<0.05	<0.05
Nitrate NO_3	< 0.1	3.52	4.56	44.9	4.5
Total Phosphorous P	< 0.01	0.03	0.04	0.2	0.03

SW3

Analysis of the annual parameters indicates a similar composition to that seen previously. The majority of the parameters are within the EQS levels for surface water. There have been slight increases in the chromium and lead concentrations during 2008. The concentration of chromium remains below the EQS for surface water, however lead marginally exceeds the EQS of 0.01mg/l. The total oxidised nitrogen concentration decreased to 1.2mg/l from 10.48mg/l in 2007. The magnesium concentration of 1,236mg/l is an increase from a level of 898mg/l in 2007. However the concentration is similar to the 2006 level of 1,232mg/l. The sodium concentration increased from levels detected in 2007 however higher levels were detected in 2005 and 2006. Sulphate decreased to a concentration of 454.1mg/l in 2008. There has been a decrease in the nitrate concentration

during 2008 to 5.3mg/l. The remainder of the annual parameters were below detection limits or within the normal range seen previously.

Table 11: SW3 – Annual Results

Parameter	Annual Results **(mg/l)**				
	Annual Nov'04	**Annual Dec'05**	**Annual Nov'06**	**Annual Nov'07**	**Annual Nov'08**
Calcium Ca	415	379.6	514.8	314.1	396.8
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	<0.0035	<0.0035
Total Chromium Cr	0.083	< 0.01	<0.01	0.012	0.017
Copper Cu	0.344	< 0.015	<0.015	0.017	<0.015
Iron Fe	0.62	< 0.03	0.26	0.287	< 0.03
Lead Pb	< 0.049	< 0.002	<0.002	<0.049	0.012
Magnesium Mg	587	1,048	1,232	898	1,236
Manganese Mn	0.201	< 0.014	0.019	0.084	< 0.014
Mercury Hg	< 0.0005	< 0.0005	<0.0005	<0.0005	<0.0005
Potassium K	378	332.1	443.2	282.9	365.1
Sodium Na	6,090	8525	9875	6171	7093
Sulphate SO_4	3,568	1,383.1	1421	2909	454.1
Zinc Zn	0.096	< 0.011	<0.011	0.014	0.014
Total alkalinity (as $CaCO_3$)	103	112	130	131	123
Total oxidised nitrogen TON	2,038	0.81	1.17	10.48	1.2
Nitrite NO_2	< 0.1	0.08	<0.05	<0.05	<0.05
Nitrate NO_3	9,061	3.52	5.21	46.6	5.3
Total Phosphorous P	< 0.01	0.02	0.04	0.89	0.01

SUMMARY OF SURFACE WATER MONITORING

As mentioned previously, the composition of the surface water is strongly influenced by the tidal nature of the estuary due to the location of the site within Cork Harbour. This results in all of the monitoring points having a naturally elevated electrical conductivity, chloride, magnesium, potassium, sodium and sulphate concentration.

It is considered that the landfilling activities are not significantly impacting on the surface water quality in the vicinity of the site. There has been no significant change in the characteristics of the surface water since the monitoring programme commenced at the site, with the exception of an increase in total phosphorous at SW1 and an increase in lead at SW2 and SW3. With the exception of lead and sulphate, the concentrations of the annual parameters tend to be within the EQS levels for surface waters. There has been a reduction in nitrate, total oxidised nitrogen and sulphate at all the monitoring locations during 2008.

GROUNDWATER MONITORING PROGRAMME

Monitoring of the groundwater compositions was undertaken at five locations (BH1, BH2, BH3, BH4, BH6) within and in the vicinity of the landfill site during 2008. In accordance with the Waste Licence for the site, monitoring of the groundwater composition at the site is undertaken on a monthly, quarterly and annual basis. During 2007, revised trigger levels were calculated for the concentration of ammoniacal nitrogen, electrical conductivity and total organic carbon in groundwater at monitoring locations BH1, BH2 and BH3.

Groundwater Levels

The monitoring of groundwater levels is undertaken on a monthly basis. The lowest groundwater levels were recorded in May and June in BH2. The lowest groundwater levels were measured in BH1 in June, in BH3 in April and June and in BH4 in October 2008. Borehole BH6 was dry between February and June and in August 2008. The groundwater levels for 2008 are shown in Table 12.

Table 12: Groundwater Levels for 2008

Month	BH1 (m bgl)	BH2 (m bgl)	BH3 (m bgl)	BH4 (m bgl)	BH6 (m bgl)
January	5.35	11.3	3.23	2.19	2.97
February	2.60	11.60	4.00	2.40	Dry
March	5.60	11.37	4.00	2.66	Dry
April	5.95	12.07	4.07	2.85	Dry
May	5.92	12.10	3.68	2.60	Dry
June	6.00	12.10	4.07	2.57	Dry
July	5.45	11.48	3.38	2.11	3.54
August	5.77	11.80	3.50	2.33	Dry
September	5.71	11.75	3.47	2.19	3.72
October	5.95	6.92	2.12	3.43	no access
November	5.7	11.60	3.20	2.16	3.59
December	5.87	11.91	3.49	2.35	3.14

Water Temperature

Monitoring of the temperature of the groundwater is undertaken on a monthly basis in the groundwater monitoring boreholes within and in the vicinity of the landfill site. The temperature data is presented in Table 13.

Table 13 – Water Temperatures for 2008

Month	BH1 (° C)	BH2 (° C)	BH3 (° C)	BH4 (° C)	BH6 (° C)
January	10.8	9.8	10.2	10.1	10.8
February	7.1	6.7	6.5	6.6	Dry
March	11.5	13.3	10.9	9.6	Dry
April	11.4	14.0	10.9	10.9	Dry
May	11.5	14.6	12.0	11.3	Dry
June	11.9	14.1	12.5	11.8	Dry
July	12.5	14.1	13.0	14.1	15.2
August	12.8	14.0	13.7	13.4	Dry
September	12.7	13.5	12.5	14.1	10.9
October	12.9	13.1	12.9	12.7	no access
November	12.8	13.8	12.8	12.3	12.5
December	12.9	13.5	12.8	13.0	12.5

pH

Monthly monitoring of the pH is undertaken. A summary of the results is presented in Table 14. The results indicate a pH range from 6.30 to 7.96 during 2008. There is no significant difference between the results for this year's monitoring period and the previous two years (2006 & 2007).

Table 14: Groundwater pH (ph units)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
BH1	6.35	7.56	6.92	6.93-7.71
BH2	6.30	7.06	6.79	6.45-7.29
BH3	6.59	7.43	6.87	6.76-7.81
BH4	6.43	7.96	6.84	6.76-7.37
BH6	6.94	7.96	7.42	6.70-7.64

Electrical Conductivity

A summary of the results of the electrical conductivity monitoring is shown in Table 15. Electrical conductivity is measured on a monthly frequency. The electrical conductivity is affected by the proximity of the sampling locations to the estuary and tidal influence. BH-1, and BH-3 displayed values above previous ranges seen in 2006 and 2007. The trigger level for electrical conductivity was exceeded in BH-1 during May and June and from August to November 2008. However, during December 2008, the electrical conductivity concentration reduced to below the trigger level. BH-3 exceeded the trigger level on one occasion only, during January 2008. The trigger level was not exceeded at BH2.

Table 15: Groundwater – Electrical Conductivity (us/cm)

Monitoring Location	Minimum	Maximum	Average	Range (2007)	Trigger Level
BH1	874	8,840	2,843	656-1,904	2,000
BH2	669	31,700	8,527	1,262-37,300	33,000
BH3	3,820	44,700	8,400	1,142-9,270	15,500
BH4	9,040	31,600	19,778.5	8,120-44,800	
BH6	306	3,750	1,320	307-34,900	

Ammoniacal Nitrogen

The results of the monthly monitoring of the ammoniacal nitrogen levels are summarised in Table 16. The average values range from <0.01 to 165mg/l. With the exception of BH6, the results are above 2006 and 2007 ranges. The levels are lowest and relatively constant in BH1 and BH2. The trigger level of 4mg/l for BH1 was exceeded during September and October 2008. The trigger level of 10mg/l for BH2 was exceeded on one occasion in January during 2008. However, higher levels were detected in BH1 in July of 2005 (8.87mg/l) and in BH2 in May of 2005 (58mgl). BH3 shows great variation in concentration and the highest overall levels of ammoniacal nitrogen were recorded in BH3. A level of > 115 mg/l was measured in BH3 in May and June 2008. However, higher levels were detected in BH3 in August of 2005 (208.7mg/l) and in September of 2005 (209mgl). These do not represent exceedances as trigger levels were exceeded on only two out of twelve sampling occasions in BH1 and BH3 and on just one out of twelve sampling occasions in BH2. The concentration of ammoniacal nitrogen during April of 2008 (160mg/l) exceeded previously detected ranges. However, excluding the April result, the 2008 range at BH4 is 0.01 to 0.21mg/l.

Table 16: Groundwater – Ammoniacal Nitrogen (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)	Trigger Level
BH1	0.51	8.2	2.6	<0.01-2.15	4
BH2	<0.01	42	3.76	0.02-9.4	10
BH3	0.01	165	66.08	18-120	115
BH4	0.01	160	13.40	<0.01-7.9	
BH6	0.01	0.51	0.182	<0.01-14.57	

Total Oxidised Nitrogen

The results of total oxidised nitrogen were quite variable in 2008 and 2007 in comparison to 2006 when concentrations were quite constant at the site. Levels in BH1and BH2 exceeded 2006 and 2007 ranges, however higher or similar levels were previously detected. A range of <0.1 to 7.63mg/l was detected in BH1 during 2004 and a concentration similar to that detected in BH2 (84.15mg/l) was also detected during Quarter 3 of 2003 (83.25mg/l). The highest level was seen in BH2 during Quarter 3 when a level of 84.15 mg/l was measured, however the concentration reduced to 20.34mg/l during the 4th Quarter of 2008.

Table 17: Groundwater – Total Oxidised Nitrogen (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
BH1	0.94	6.06	2.94	0.56-2.4
BH2	1.33	84.15	27.2	0.6-9.09
BH3	<0.1	0.44	0.23	<0.1-<0.1
BH4	2	3.94	2.91	0.16-8.82
BH6	n/a	n/a	n/a	12.47-12.74

Total Organic Carbon

Revised trigger levels for the concentration of total organic carbon were calculated during 2007 at monitoring locations BH1, BH2 and BH3. The limit was exceeded in BH1 during Quarter 4 when a level of 29.6mg/l was measured. The limit was also exceeded in BH3 during Quarter 4 when a level of 86mg/l was detected. However the limit was not exceeded on three out of four of the sampling occasions at BH1 and BH3 during 2008. The limit was not exceeded in BH-2.

Table 18: Groundwater – Total Organic Carbon (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)	Trigger Levels
BH1	10.3	29.6	18.57	5.4-9.8	22
BH2	3	25	17.2	14-185	36
BH3	20.5	86	40.5	12.4-50	82
BH4	19.7	78	52.5	<0.4-80	
BH6	n/a	n/a	n/a	21.1-21.1	

Potassium

A summary of the concentration of potassium is shown in Table 19. With the exception of BH1 the potassium concentrations are within ranges detected during 2006 and 2007. However. a range of 12.7 to 26.33mg/l was detected for potassium in BH1 during 2005. It is not unusual to see a wide variation in the concentration of potassium as the groundwater chemistry is strongly influenced by the proximity of the boreholes to the estuary.

Table 19: Groundwater – Potassium (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
BH1	8.34	16.53	13.95	6.54-9.49
BH2	6.21	170.1	65	57.18-420.6
BH3	33.34	82.62	64.02	47.38-88.79
BH4	83.59	174.2	138.3	15.6-271.3
BH6	3.17	3.17	3.17	3.17-3.17

Sodium

The results of sodium monitoring are shown in Table 20. The concentration levels in the monitoring boreholes are within ranges detected during 2006 and 2007.

Table 20: Groundwater – Sodium (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
BH1	63.1	400.2	196.2	19.28-69.01
BH2	28.06	936.3	367.46	358.1-4,100
BH3	386.2	873.7	563.85	117.1-1,336
BH4	28.51	3,433	2,036.4	352.9-1,526
BH6	8.97	8.97	8.97	357

Chloride

A summary of the results of the chloride monitoring are presented in Table 21. With the exception of BH1, the chloride concentration at all monitoring locations was within ranges seen at the site during 2006 and 2007. The concentration of BH1 during Quarter 3 exceeded previously detected levels, however the concentration reduced to within 2006 and 2007 ranges during Quarter 4, 2008.

Table 21: Groundwater – Chloride (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
BH1	132.2	2,224	715.77	33.8-269.5
BH2	448.5	1,078	1,588.4	2,745-14,793
BH3	398.4	1,892	962.05	271.7-3,170.5
BH4	326	7,234	3,496.65	3,465-27,857
BH6	247.9	247.9	247.9	5,620

ANNUAL GROUNDWATER MONITORING PARAMETERS

BH1

The results of the analysis of the annual parameters in 2008 indicate a similar composition to that seen in 2006 and 2007. The monitoring results have been compared to the Interim Guideline Values (IGV) for groundwater recommended by the EPA in the publication "Towards Setting Guideline Values For The Protection Of Groundwater In Ireland". None of the parameters exceed the IGV values for groundwater as recommended by the EPA. There has been a reduction in the total cyanide, total alkalinity, boron, fluoride and total phosphorous concentrations in 2008 compared to levels recorded in 2007. There has been an increase in the sulphate concentration to 152.26mg/l (which does not exceed the IGV of 200mg/l) in 2008 compared to 63.75mg/l in 2007 and 43.8 mg/l in 2006. The concentration of calcium has increased to 166.3mg/l from 135.1mg/l in 2007 and 134.5mg/l in 2006. However the IGV of 200mg/l for calcium is not exceeded. Increases were also detected in the concentrations of lead and magnesium. However the IGV's for lead and magnesium were not exceeded.

Table 22: Annual BH1 Results

Parameter	**Results** (mg/l)			
	Annual Dec'05	**Annual Nov '06**	**Annual Nov '07**	**Annual Nov '08**
Residue on evaporation	655	84	596	1721
Calcium Ca	112.2	134.5	135.1	166.3
Cadmium Cd	< 0.0035	<0.0035	<0.0035	<0.0035
Total Chromium Cr	< 0.01	<0.01	<0.01	<0.01
Copper Cu	< 0.015	<0.015	<0.015	<0.015
Total Cyanide Cn	0.016	0.006	0.008	0.003
Iron Fe	0.07	1.262	<0.03	<0.03
Lead Pb	< 0.002	0.003	<0.002	0.01
Magnesium Mg	14.13	27.61	14.48	35.6
Manganese Mn	1.018	1.887	0.009	0.048
Mercury Hg	< 0.0005	<0.0005	<0.0005	<0.0005
Sulphate SO_4	27.91	43.8	63.75	152.26
Zinc Zn	< 0.011	0.02	<0.011	
Total alkalinity (as $CaCO_3$)	349	361	365	355
Boron B	0.142	0.357	0.253	0.129
Fluoride F	0.14	<0.08	0.51	<0.08
Total Phosphorus P	0.01	0.02	0.01	<0.01
Faecal coliforms (CFU/100mls)	3	162	1	None Found
Total coliforms (CFU/100mls)	613	7	272	275

BH2

The results of monitoring of the annual parameters in 2008 indicate that the concentration is similar to that seen previously with the majority of the parameters being less than the IGV for groundwater. The concentration of total cyanide increased slightly to 0.019mg/l, exceeding the IGV of 0.01mg/l. Lead increased to a level of 0.005mg/l. However the level is below the IGV of 0.01mg/l. There has been a decrease in the residue on evaporation to 1,280mg/l in 2008 from 10,432mg/l in 2007 from 7,750mg/l in 2006 and 5,850mg/l in 2005. There has been a decrease in the iron concentration to below the detection limit of <0.03mg/l from 0.087mg/l in 2007. The fluoride concentration decreased in 2008 to below the detection limit and IGV level of 1.0mg/l at <0.08mg/l. Reductions were also noted in the concentrations of calcium, chromium, magnesium, manganese, boron, sulphate and total phosphorous were seen in 2008.

Table 23: BH2 – Annual Results

Parameter	Results (mg/l)			
	Annual Dec'05	Annual Nov '06	Annual Nov '07	Annual Nov '08
Residue on evaporation	5,850	7,750	10,432	1,280
Calcium Ca	310.7	196.2	269.8	248.9
Cadmium Cd	< 0.0035	<0.0035	<0.0035	<0.0035
Total Chromium Cr	< 0.01	0.013	0.01	<0.01
Copper Cu	< 0.015	<0.015	<0.015	<0.015
Total Cyanide Cn	0.011	0.016	0.008	0.019
Iron Fe	0.041	<0.03	0.087	<0.03
Lead Pb	0.007	<0.002	<0.002	0.005
Magnesium Mg	217.5	187.6	228.1	95.34
Manganese Mn	3.279	3.925	0.805	<0.014
Mercury Hg	< 0.0005	<0.0005	<0.0005	<0.0005
Sulphate SO_4	170.7	439.9	646	373.6
Zinc Zn	0.082	0.014	<0.011	<0.011
Total alkalinity (as $CaCO_3$)	465	515	455	500
Boron B	0.84	0.838	0.892	0.338
Fluoride F	6.8	8.84	7.9	<0.08
Total Phosphorus P	0.01	0.01	0.07	<0.01
Faecal coliforms (CFU/100mls)	1	4	8	1
Total coliforms (CFU/100mls)	290	345	8,150	3,120

BH3

Analysis of the annual parameters in 2008 indicated that the majority of the parameters were within the normal levels seen at the site with some minor changes. The results are compared to 2005 and 2006 results, as the borehole was dry in November 2007. The concentration of total cyanide increased from levels in 2005 and 2006. The level of lead increased to 0.024mg/l, above the IGV of 0.01mg/l, from a level below the detection limit in 2006. Decreases occurred in the levels of residue on evaporation, iron, magnesium, manganese, sulphate, zinc, total alkalinity, boron, fluoride, total phosphorous and total and faecal coliforms since 2006.

Table 24: BH3 – Annual Results

Parameter	Results (mg/l)			
	Annual Dec'05	Annual Nov '06	Annual Nov '07	Annual Nov '08
Residue on evaporation	3096		Dry	2643
Calcium Ca	112.1	56.52		129.8
Cadmium Cd	< 0.0035	<0.0035		<0.0035
Total Chromium Cr	0.089	<0.01		<0.01
Copper Cu	0.048	0.022		0.023
Total Cyanide Cn	0.001	0.014		0.055
Iron Fe	2242	0.721		0.404
Lead Pb	0.004	<0.002		0.024
Magnesium Mg	100.6	129.5		64.5
Manganese Mn	5.08	0.832		0.101
Mercury Hg	< 0.0005	<0.0005		<0.0005
Sulphate SO_4	32.35	298.7		229.9
Zinc Zn	0.03	0.021		<0.011
Total alkalinity (as $CaCO_3$)	600	490		211
Boron B	0.705	0.804		0.445
Fluoride F	2.25	2.19		<0.08
Total Phosphorus P	0.01	0.05		<0.01
Faecal coliforms (CFU/100mls)	600	16		None Found
Total coliforms (CFU/100mls)	3096	3200		119

BH4

Analysis of the annual parameters in 2008 indicated that all of the parameters were within the normal levels seen at the site with the exception of residue on evaporation and total phosphorous. The level of residue on evaporation increased to 11,010mg/l above recently detected ranges. Total phosphorus increased from 0.17mg/l to 0.31mg/l in 2008. There have been decreases in the concentrations of calcium, cadmium, copper, chromium and iron from 2007 levels, and in total cyanide, iron, manganese, zinc, boron, fluoride and sulphate from 2006 and 2007 levels.

BH4 – Annual Results

Parameter	**Results (mg/l)**			
	Annual Dec'05	**Annual Nov '06**	**Annual Nov '07**	**Annual Nov '08**
Residue on evaporation	10,426	10,094	4,103	11,010
Calcium Ca	135.7	132.4	455.8	133.5
Cadmium Cd	< 0.0035	<0.0035	0.028	0.007
Total Chromium Cr	< 0.01	<0.01	0.09	<0.01
Copper Cu	0.019	<0.015	4.314	0.057
Total Cyanide Cn	0.001	0.004	0.007	0.001
Iron Fe	0.21	0.196	1.614	0.039
Lead Pb	0.003	<0.002	0.406	0.109
Magnesium Mg	332	312.5	123.3	263.4
Manganese Mn	0.097	0.062	1.451	<0.014
Mercury Hg	< 0.0005	<0.0005	<0.0005	<0.0005
Sulphate SO_4	620.3	1005.2	3,022	457
Zinc Zn	< 0.011		0.015	<0.011
Total alkalinity (as $CaCO_3$)	234		176	306
Boron B	1.633	0.952	2.802	0.752
Fluoride F	13.98	11.43	64.4	<0.08
Total Phosphorus P	0.14	0.12	0.17	0.31
Faecal coliforms (CFU/100mls)	9	22	2850	225
Total coliforms (CFU/100mls)	2419	3200	0	4280

BH6

The results are compared to 2005 and 2006 results, as the borehole was dry in November 2007. The results of the annual monitoring in 2008 indicated most of the parameters were within normal ranges and IGV values. The concentration of lead increased slightly to 0.009mg/l, however the concentration remains below the IGV of 0.01mg/l. Sulphate increased to 189.3mg/l exceeding previously detected ranges, however the concentration remains below the IGV of 200mg/l. There was an increase in the level of total phosphorous above 2005 and 2006 levels. The levels of boron, calcium, fluoride, total cyanide, iron and magnesium reduced in 2008, compared to levels seen in 2005 and 2006.

Table 25: BH6 - Annual Results

Parameter	Results (mg/l)			
	Annual Dec'05	Annual Nov '06	Annual Nov '07	Annual Nov '08
Residue on evaporation	343		Dry	417
Calcium Ca	54.34	22.59		21.76
Cadmium Cd	< 0.0035	<0.0035		<0.0035
Total Chromium Cr	< 0.01	<0.01		<0.01
Copper Cu	0.043	<0.015		<0.015
Total Cyanide Cn	0.001	0.009		<0.001
Iron Fe	0.043	0.187		<0.03
Lead Pb	0.002	0.002		0.009
Magnesium Mg	9.8	8.52		4.7
Manganese Mn	0.057	<0.014		<0.014
Mercury Hg	< 0.0005	<0.0005		<0.0005
Sulphate SO_4	18.32	17.8		189.3
Zinc Zn	0.012			<0.011
Total alkalinity (as $CaCO_3$)	103	50		66
Boron B	0.234	0.199		0.055
Fluoride F	1.52	1.53		0.39
Total Phosphorus P	0.02	0.02		0.62
Faecal coliforms (CFU/100mls)	29	980		1553
Total coliforms (CFU/100mls)	> 2419	14		6580

SUMMARY OF GROUNDWATER MONITORING

Analysis of the annual parameters was undertaken during November, 2008. The groundwater chemistry is strongly influenced by the proximity of the boreholes to the estuary. This results in a naturally elevated chloride, electrical conductivity, sodium, potassium, magnesium and sulphate concentration.

Reductions in the concentrations of a number of parameters occurred during 2008, including boron, fluoride, iron, magnesium, zinc and sulphate. The results of the annual monitoring indicate an increase in the concentration of lead at each of the monitoring boreholes with the exception of BH4. However the concentration of lead is below the interim guideline values recommended by the EPA at BH1, BH2 and BH6.

Considerable variation is seen in the boreholes in the ammoniacal nitrogen level, TOC and TON and while these are on occasion above the interim guideline values recommended by the EPA, they are in keeping with historical records of this site. The concentration of ammoniacal nitrogen remains high at groundwater monitoring location BH3, but is within the normal range seen previously at the site.

LEACHATE MONITORING

Monitoring of the leachate composition is undertaken at the leachate lagoon and from three monitoring points within the former unlined portion of the site (C1, C2 and C3). Monitoring of leachate composition is undertaken on a quarterly basis with analysis of a wider range of parameters on an annual basis. Leachate level monitoring is undertaken by Cork County Council.

pH

The results of monitoring are summarised in Table 26. The overall pH in the leachate lagoon has ranged from 7.18 to 8.77 pH units during 2008 compared to a range of 7.95 to 8.25 pH units in 2007 and 7.86 to 7.98 in 2006. The range in the unlined and capped portion of the site has ranged from 6.53 to 8.51 pH units during 2008. The results during 2007 are similar to those seen during previously at the site.

Table 26: Leachate pH (pH units)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	7.18	8.77	7.90	7.95-8.25
C1	7.41	7.96	7.73	6.78-7.58
C2	6.53	7.45	7.11	6.73-7.12
C3	7.31	8.51	7.98	7.58-7.93

Electrical Conductivity

The results of the monitoring of the electrical conductivity for the 2008 are summarised in Table 27. As seen previously at the site considerable variation is seen in the electrical conductivity at all of the monitoring locations. There has been a decrease in the range in electrical conductivity at the leachate lagoon compared to the ranges seen in 2006 and 2007. The electrical conductivity at C3 decreased from 29,900 to 41,350 uS/cm in 2007 compared to 17,600 to 43,600 us/cm in 2007. Increases in electrical conductivity concentrations occurred at C1 and C2. The concentration at C1 increased to 31,650 uS/cm during Quarter 4, however, a range of 8,222 to 36,800uS/cm was detected in 2004. The concentration at C2 increased to 8,080uS/cm during Quarter 4, 2008. However, a range of 3,130 to 16,070uS/cm was detected in 2005.

Table 27: Leachate – Electrical Conductivity (us/cm)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	701	8,900	6,166.5	9,040-17,680
C1	18,600	31,650	23,662.5	3,910-15,990
C2	5,140	8,080	6,346.25	5,330-6,520
C3	29,900	41,350	33,387.5	17,600-43,600

Ammoniacal Nitrogen

A summary of the results of the monitoring is presented in Table 28. The concentrations seen during this monitoring period exceed the ranges detected during 2006 and 2007 with the exception of the Lagoon. The concentration of ammoniacal nitrogen in the lagoon decreased during to 2008 to a range of 3.2 to 551mg/l from a range of 485 to 970mg/l in 2007 and 861 to 1,149mg/l in 2006. Ammoniacal concentrations at C1 (1,770 to 2,660mg/l) exceed 2006 and 2007 ranges, however similar high levels were detected in 2005 (2,430mg/l), 2004 (2,490mg/l) and a range of 2,450 to 4,800mg/l in 2003. A concentration range of 228 to 3,550mg/l was detected in C2 during 2005 and a concentration range of 3.160 to 6,000mg/l was detected in C3 during 2003.

Table 28: Leachate – Ammoniacal Nitrogen (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	3.2	551	447.3	485-970
C1	1,770	2,660	2382.5	237.5-576
C2	400	800	594.25	313-440
C3	2,000	5,900	4,044.25	294-4,600

Biochemical Oxygen Demand

The results for the biochemical oxygen demand are summarised in Table 29. As seen previously there is considerable variation in the results for all the monitoring boreholes. The overall BOD levels in 2008 ranged 27 to 1,276 mg/l in the leachate lagoon and from 23 to 1,439 mg/l in the unlined capped portion of the site. The results for 2008 are above the 2006 and 2007 ranges in the Lagoon and at C1. The concentration of BOD in the lagoon, C1 and C2 increased during Quarter 4, 2008, exceeding the 2007 range. However the 2006 range of 23 to150mg/l at C2 was not exceeded during 2008 and a range of 91 to 331mg/l was detected at C1 during 2005. The concentration of BOD at the leachate lagoon during Quarter 4 (1,276mg/l) exceeded previously detected levels.

Table 29: Leachate – Biochemical Oxygen Demand (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	27	1,276	402.5	167-308
C1	48	231	133	22-105
C2	23	140	67	21-53
C3	476	1,439	934.5	1,500-8,424

Chemical Oxygen Demand

The COD levels in the leachate lagoon ranged from 150 to 2,200 mg/l in 2008 compared to 600 to 7,200mg/l in 2007. The monitoring results in the unlined uncapped portion of the site range from 180 to 8,150mg/l in 2008 compared to 80 to 59,200 mg/l in 2007. There is less variation in the COD concentration at the lagoon and at monitoring point C3 than 2007 levels. During the monitoring period the concentration range in the leachate lagoon reduced from 600 to 7,200mg/l in 2007 to 150 to 2,200mg/l in 2008. The concentration range of COD also reduced at monitoring point C3 (1,600 to 8,150mg/l) during 2008.

The COD level at C1 exceeded the 2007 range but remained within the 2006 range of 170 to 1,090mg/l. The COD level at C2 exceeded the 2007 and 2006 range but remained within the 2005 range of 160 to 5,400mg/l.

Table 30: Leachate – Chemical Oxygen Demand (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	150	2,200	1,180	600-7,200
C1	500	1,060	785	190-790
C2	180	400	297.5	80-300
C3	1,600	8,150	4,087.5	6,200-59,200

Chloride

The chloride results are shown in Table 31. A considerable variation in the chloride concentration is seen at all the monitoring points. During 2008 the chloride concentration ranged from 529 to 12,821 mg/l in the leachate lagoon. This range is an increase in the ranges seen in 2006 and 2007. The concentration during Quarter 1 (12,821mg/l) exceeds previously detected levels. However, the chloride concentration during Quarters 2 to 4 (529 to 1,274) decreased to within 2006 and 2007 ranges. The chloride range in the monitoring boreholes in the unlined capped portion of the site for 2008 (258 to 4,800mg/l) is slightly above the range seen in 2007 (251 to 4,024 mg/l) and 2006 (134.2 to 3,568 mg/l) but is within the range seen in 2005 (217.1 to 11,980 mg/l).

Table 31: Leachate – Chloride (mg/l)

Monitoring Location	Minimum	Maximum	Average	Range (2007)
Lagoon	529	12,821	3,698	1,065-2,404
C1	4,650	4,800	4,731	624-4,024
C2	258	1,323	826.75	641-943
C3	2,914	3,100	3,045	251-3,924

ANNUAL LEACHATE PARAMETERS

Analysis of the annual parameters was undertaken during November 2008. The composition of the leachate monitored at the site during the current monitoring period is similar to that seen previously at the site. A wide variation is seen in most of the parameters monitored.

LEACHATE LAGOON

Results from the 2008 annual monitoring are compared to the 2006 monitoring results, as the lagoon was dry at the time of sampling in November 2007.

During 2008 many of the parameters were within the limits set for drinking water i.e. calcium, chromium, copper, mercury, sulphate, zinc, nitrite and nitrate. There were increases in the levels of calcium, cadmium, lead, total alkalinity, total cyanide and total and faecal coliforms, with each except calcium exceeding the drinking water limit.

Table 32: Leachate Lagoon – Annual Results

Parameter	Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	28.3	38.2	125.5	Dry	191.2
Cadmium Cd	< 0.0035	< 0.0035	<0.0035		0.021
Total Chromium Cr	0.067	0.098	0.112		0.01
Copper Cu	< 0.015	0.026	0.046		<0.015
Iron Fe	5.04	7.215	16.44		2.499
Lead Pb	< 0.049	0.015	<0.049		0.012
Magnesium Mg	19.6	40.5	134.3		86.76
Manganese Mn	3.3	0.414	1.045		0.978
Mercury Hg	< 0.0005	< 0.0005	0.0008		< 0.0005
Potassium K	130	313.7	792.6		328.3
Sulphate SO_4	4.22	8.08	147.4		13.82
Zinc Zn	0.283	0.018	0.099		<0.011
Total alkalinity (as $CaCO_3$)	549	1980	1670		2760
Total oxidised nitrogen (as N)	0.57	0.9	1.26		0.53
Total Phosphorous	0.36	3	4.75		0.4
Boron B	4.43	5.838	3.494		1.662
Total Cyanide	0.005	0.01	0.006		0.115
Nitrite NO_2	< 0.1	< 0.1	<0.1		<0.1
Nitrate	2.56	3.98	5.8		0.53
Fluoride F	1.39	3.86	13.6		13.31
Faecal Coliforms	209	100	165		212
Total Coliforms	> 24,190	7701	5250		6520

C1

The results of the annual monitoring indicate a similar composition to that seen previously, with some exceptions outlined below. There has been an increase in the concentration of copper to 0.327mg/l compared to a level of 0.237 mg/l in 2007, however the concentration is less than the drinking water limit of 2mg/l. There has been an increase in the magnesium concentration to a level of 229.18mg/l in 2008 compared to a concentration of 125.6 mg/l in 2007 and <0.01 mg/l in 2006. Potassium increased to a concentration of 1,313mg/l from 125.4mg/l in 2007. However, a concentration of 1,339mg/l was detected in 2005 and 1,510mg/l in 2004. An increase was also detected in the level of total cyanide in comparison to previously detected levels. There have been decreases in the levels of calcium, chromium, iron, lead, sulphate, zinc, TON, total phosphorus, boron, nitrate and fluoride compared to previous levels in 2007.

Table 33: C1 – Annual Results

Parameter	Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	117	80.3	0.34	121.1	115.2
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	0.0035	0.033
Total Chromium Cr	0.133	0.102	0.022	0.027	<0.01
Copper Cu	0.41	0.016	<0.015	0.237	0.327
Iron Fe	74.1	204.4	0.466	2.544	0.299
Lead Pb	< 0.049	0.08	<0.049	0.28	0.016
Magnesium Mg	212	186.8	<0.01	125.6	229.8
Manganese Mn	0.962	0.304	4.054	<0.014	<0.014
Mercury Hg	< 0.0005	< 0.0005	<0.0005	<0.0005	<0.0005
Potassium K	1,510	1,339	<0.1	125.4	1,313
Sulphate SO_4	171.3	761.7	38.7	179.2	105.3
Zinc Zn	1.09	0.02	0.016	0.012	<0.011
Total alkalinity (as $CaCO_3$)	5,400	5130	579	5000	4590
Total oxidised nitrogen (as N)	29.12	< 0.1	1.26	3.89	2.93
Total Phosphorous	3	3	0.05	2	0.18
Boron B	7.68	5.356	0.325	3.207	2.594
Total Cyanide	0.078	< 0.001	0.014	0.01	0.355
Nitrite NO_2	< 0.1	< 0.1	<0.1	<0.1	< 0.1
Nitrate	129.4	< 0.1	5.6	17.3	13.05
Fluoride F	353.3	9.55	0.96	4.6	0.92
Faecal Coliforms	10	None found	31	0	None Found
Total Coliforms	> 24,190	2755	2800	25000	3000

C2

The results of the annual monitoring indicate no significant change in the leachate composition the majority of the parameters are within the normal range seen at the site. There has been an increase in the cadmium concentration from <0.0035mg/l to a concentration of 0.019mg/l in 2008. There has been an increase in the total phosphorous concentration to 1.8mg/l in 2008 compared to a level of 0.75mg/l in 2007.

However a similar level of 1.5 mg/l was detected in 2004. The concentration of total cyanide increased slightly in 2008 to 0.034mg/l from a concentration of 0.03mg/l in 2007. However the 2008 level does not exceed the drinking water limit. The concentration if iron decreased from 0.386mg/l in 20007 to 0.213mg/l in 2008. During 2008 the concentration of the following parameters has been below the drinking water limit: boron, calcium, total chromium, copper, lead, magnesium, manganese, mercury, sulphate, zinc, total cyanide, nitrite, nitrate and faecal coliforms.

Table 34: C2 – Annual Results

Parameter	Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	185	228.3	224.5	122	6.18
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	<0.0035	0.019
Total Chromium Cr	0.053	0.01	<0.01	<0.01	<0.01
Copper Cu	0.147	0.017	<0.015	<0.015	<0.015
Iron Fe	13	314.1	43.03	0.386	0.213
Lead Pb	< 0.049	0.008	<0.049	0.052	0.008
Magnesium Mg	126	138	180.2	130.2	21.72
Manganese Mn	4.34	1.116	0.922	0.03	0.014
Mercury Hg	< 0.0005	< 0.0005	<0.0005	<0.0005	<0.0005
Potassium K	164	211.8	305.1	110.2	138.9
Sulphate SO_4	6.56	80.35	3.2	21.9	20
Zinc Zn	0.05	0.031	0.029	<0.011	<0.011
Total alkalinity (as $CaCO_3$)	1,900	1615	2120	1820	1070
Total oxidised nitrogen (as N)	0.71	< 0.1	0.26	1.13	0.1
Total Phosphorous	1.5	0.5	0.25	0.75	1.8
Boron B	9.41	1.754	1.712	1.911	0.718
Total Cyanide	0.148	0.029	0.032	0.03	0.034
Nitrite NO_2	< 0.1	< 0.1	<0.1	<0.1	<0.1
Nitrate	3.15	< 0.1	1.03	5	0.42
Fluoride F	5.19	1.02	6.11	13.29	<0.08
Faecal Coliforms	None found	None found	53	0	None Found
Total Coliforms	> 24,190	> 24190	3500	9208	153

C3

There has been a decrease in the calcium concentration from 292.8mg/l in 2007 to a level of 232.1 mg/l in 2008. The iron concentration has decreased from 5.907mg/l in 2007 to 0.429mg/l in 2008. A higher concentration of cadmium was detected during 2008 than previously seen (<0.0035mg/l). There has been an increase in the concentration of magnesium to 417.3mg/l from a level of 389.4mg/l in 2007. However a level of 420mg/l was detected in 2004. The concentrations of potassium, sulphate, total cyanide and zinc also increased during 2008 but higher levels were detected previously. The results of the annual parameters indicate a reduction of a number of other parameters including lead, manganese, TON and total phosphorous.

The following parameters are less than the drinking water limits: chromium, copper, iron, mercury, sulphate, zinc, nitrite, nitrate and faecal coliforms.

Table 35: C3 – Annual Results

Parameter	Results (mg/l)				
	Annual Nov'04	Annual Dec'05	Annual Nov'06	Annual Nov'07	Annual Nov'08
Calcium Ca	24.3	64.37	7.56	292.8	232.1
Cadmium Cd	< 0.0035	< 0.0035	<0.0035	0.005	0.008
Total Chromium Cr	0.292	0.038	0.026	0.141	0.01
Copper Cu	0.264	< 0.015	<0.015	0.415	<0.015
Iron Fe	35.9	456.9	0.783	5.907	0.429
Lead Pb	< 0.049	0.016	<0.049	0.602	0.048
Magnesium Mg	420	234.9	67.41	389.4	417.3
Manganese Mn	0.365	0.384	0.028	0.115	0.068
Mercury Hg	< 0.0005	< 0.0005	<0.0005	<0.0005	<0.0005
Potassium K	1,900	661.7	310.6	165.2	1347
Sulphate SO_4	36.54	1.31	16.8	9.8	13.06
Zinc Zn	1.82	0.10	0.107	<0.011	0.016
Total alkalinity (as $CaCO_3$)	18,400	6300	3670	8010	9920
Total oxidised nitrogen (as N)	99.24	2.18	0.55	15.97	0.77
Total Phosphorous	4	1.5	1.25	5	2.2
Boron B	3.01	9.475	0.694	4.05	3.864
Total Cyanide	0.487	0.06	0.342	0.043	0.13
Nitrite NO_2	< 0.1	< 0.1	<0.1	<0.1	<0.1
Nitrate	441.1	9.7	2.45	71	3.44
Fluoride F	389.6	41.77	3.12	33.5	1.37
Faecal Coliforms	None found	None found	3000	0	None Found
Total Coliforms	> 24,190	> 24190	11500	341	1355

CONCLUSIONS

With the exception of an increase in the concentration of lead in a number of the groundwater monitoring locations and surface water monitoring points SW2 and SW3, there has been no significant change in the composition of the leachate, groundwater and surface water in the vicinity of the landfill site. All of the parameters monitored were within the normal range seen previously at the site.

8 ENVIRONMENTAL EMISSIONS

8.1 Volume of Leachate Produced and Transported

The volume of leachate produced is the volume of leachate pumped to the lagoons and transported to the waste water treatment plants plus the approximate quantity remaining in both lagoons at the end of the period 1st January to 31st December 2008.

From records, this total volume is 12,785.57 tonnes or 2,869,082 gallons.

8.2 Effectiveness of Environmental Nuisance Emission Control

Noise

The degree of noise emission from the landfill was proportional to the number of plant machinery items operating at any one time. Since closure this has declined to a point where only the lesser number of vehicles involved with landfill capping provided the only sources of noise. From observations, with a small number of techniques to dampen noise, little airborne sound is evident offsite.

The site underwent phases of work intensity mainly associated with development works. Noise generated by waste placement plant used to contribute nuisance due to elevation of the work area and lack of a buffer or screen at the perimeter.

All pumps are electrically or pneumatically powered.

Dust

Dust problems on site were attributed to dry weather, fine waste, fine imported soil for development, screening, waste covering, winds, landfill development traffic and works. Other potential sources of wind-blown dust exist in the near locality.

Because the site roads are constructed of hardcore they generate dust on drying and have to be treated to water spraying by vacuum tanker daily and/or mechanical sweeping as required to comply with the Operational Plan and good work practice. Prior to completion of the capping contract the entire site will be surfaced in asphalt which will, in effect, eliminate the source of dust.

Odours

Since landfill activity has ceased odours have been completely eliminated.

Landfill Gas

An assessment of the potential production capability of the former capped landfill is enclosed in the landfill gas study by Fehily Timoney & Co contained in Appendix C, Estimation of Cumulative and Annual Landfill Gas Emissions.

The installation of the landfill gas flare coincided with the restoration of the landfill to final contour levels. The flare burns landfill gas continuously. Regular field balancing of the well connections to the manifolds yields high quality methane with the elimination of oxygen to minimum quantities. Typically, the field produces between 450m^3 per hour, depending on atmospheric conditions.

The technology to be selected that will be engaged to utilize the landfill gas resource will most likely be that which will provide the greatest financial return in order to sustain the environmental and energy requirements, post closure.

Leachatge

The main environmental protection system against emissions from leachate is the HDPE liner. Failure of this system will cause environmental pollution. The liner is safeguarded in the sense that it is largely located underground with the exception of the lagoons which are fenced off. It is intrinsically safe from damage and the possibility of leakage is removed.

Litter

Litter no longer presents a nuisance either on or offsite.

Vermin

A contract was in place with a pest control firm, PestGuard Ltd., who visit the site fortnightly. Bait is set at six-week intervals by site staff. Experience has shown that less or more frequent baiting is ineffective and not in accordance with bait manufacturers' recommendations.

Birds

Birds no longer present a nuisance on the site

The Waste Licence prohibits the use of a physical strategy against birds.

Attempts at implementation of the Condition 6.8 of the Waste Licence came with no inconsiderable cost.

8.3 Meteorological Report

Weather
The Vaisala 101 weather station was installed with the commencement of the Waste Licence on the capped landfill and connected to the pc in the landfill manager's office.

The datalogger on the weather station can store up to sixty day's weather information at a time. The read-out is a comprehensive recording of all relevant daily and hourly weather parameters.

Complete daily weather records for the landfill are enclosed in Appendix D.

The total rainfall for 200 at the landfill was recorded at 1043.4mm. The peak month for rainfall was again July as in 2007 with 166.2mm and the lowest was April with 26.8mm. The maximum rainfall for any one day was 49.4mm on Tuesday 9th September.

The warmest day was Monday 9th June with 25.0°C and the coldest was Friday 4th January with -3.5°C.

The highest relative humidity was 98.8% on Friday 28th November and the lowest was on Friday 9th June with 16.9%.

The highest atmospheric pressure was recorded at 1038.6 on Saturday 16th February and the lowest was 973.8 on Tuesday January 15th.

The strongest winds were experienced on Tuesday March 11th with 29.2m/s.
Complete hourly weather records for the landfill are held on the office pc for reference.

Monthly Rainfall Statistics

Month	Rainfall mm
January '08	140.0
February '08	41.4
March '08	82.6
April '08	26.8
May '08	86.4
June '08	91.4
July '08	166.2
August '08	115.2
September '08	127.2
October '08	78.2
November '08	54.2
December '08	33.8

Total rainfall	1043.4mm

9 OBJECTIVES AND TARGETS

9.1 Schedule of Objectives and Targets

In accordance with Condition 2.2 of the facilities waste licence, specific objectives and targets have been identified, along with a programme for their implementation.

The schedule of objectives and targets for 2009 are outlined in Table 1:

Table 9.1: Schedule of Objectives and Targets

Objective No.	Objective	Target
1	To monitor and control landfill gas and odour emissions at the facility	Continue efficient control of landfill gas at the facility
2	To promote sustainable energy options and increase the energy efficiency of the facility	Identity at least one feasible sustainable option by December 2009
3	To improve the efficiency of operation and monitoring of the leachate and stormwater management system	Ensure compliance with Condition 4.18 of the waste licence with reference to leachate management
4	To identify possibilities for the after-use of the landfill area following restoration	Identify an after-use plan for the landfill by the end of 2009
5	To maximise the efficiency and continuously improve operations at the civic amenity facility.	To increase the efficiency of the civic amenity and reduce security breaches.
6	Review closure modifications of the Waste Licence following the closure of the landfill facility	Reduce the monitoring requirements and schedules following closure of the landfill
7	Review staffing levels across the organisation to enable a continual service to the public	Ensure minimum staff levels on site to prevent facility closure

Environmental Management Programme

An Environmental Management Programme (EMP) is a programme for achieving the Schedule of Objectives and Targets. This programme defines the principal tasks to be undertaken to achieve the objectives and targets. It identifies those responsible for the carrying out the tasks and the scheduled timeframe for the tasks to be completed.

East Cork Landfill's Environmental Management Programme (EMP) is available in Table 2 below:

Objective No.	Objective	Target	Tasks	Person Responsible	Estimated Completion Date
1	To monitor and control landfill gas and odour emissions at the facility	Continue the efficient control of landfill gas at the facility	Ensure the correct abstraction of landfill gas and operation of the landfill gas flare at the facility.	Jerome O'Brien	January 2009-onwards
			Balance the landfill gas collection system monthly and maintain records	Lisa Collins	Ongoing
			Ensure the correct operation of the remote monitoring and alarm system to control the operation of the flare especially at night-time, on Sundays and Bank Holidays.	Jerome O'Brien	January 2009
			Carry out a gas audit to optimise the gas collection and ensure proper control of the gas field. This will be advantageous for the utilisation of landfill gas at the facility.	Jerome O'Brien	April 2009
			Following completion of the capping of the landfill facility repeat the OMI odour/VOC survey to ensure no landfill gas leakage is detected.	Jerome O'Brien	June 2009
			Establish a contact for the provision of a back up power generator for the operation of the gas flare, in the case of a planned cut in power supply	Jerome O'Brien	March 2009
2	To promote sustainable energy options and increase the energy efficiency of the facility	Identity at least one feasible sustainable energy option by December 2009	Request expressions of interest from interested parties to establishing a contract to design, build, operate and finance the complete gas collection, utilisation and flaring system at the landfill.	Jerome O'Brien	March 2009
			Explore the market options for utilising the grass growing at the landfill to generate biogas for use as an energy source	Jerome O'Brien	September 2009

Objective No.	Objective	Target	Tasks	Person Responsible	Estimated Completion Date
3	To improve the efficiency of operation and monitoring of the leachate and stormwater management system	Ensure compliance with Condition 4.18 of the waste licence with reference to leachate management	Maintenance and calibration of the stormwater pond control equipment to ensure correct operation of the equipment	Jerome O'Brien	Bi-annual Ongoing
			Examine the possibility of a flow meter on the outlet of the stormwater pond and if this can be connected to the SCADA system onsite	Jerome O'Brien	September 2009
			Carry out a study on the upper and lower limits used to control the actuated valve on the stormwater pond, to ensure correct operation.	Jerome O'Brien	July 2009
			Set up a training manual to contain maintenance, sampling and monitoring procedures for the stormwater pond and ensure all personnel are trained on its operation.	Lisa Collins	April 2009 Training Ongoing
			Test and commission the SCADA control of the leachate recirculation recently installed. Ensure leachate levels are in compliance with the facilities waste licence	Jerome O'Brien	March 2009 Ongoing
4	To identify possibilities for the afteruse of the landfill area following restoration	Identify an after-use plan for the landfill by the end of 2009	Carry out a feasibility study into the possibilities for after use of the landfill area following restoration	Jerome O'Brien	December 2009
5	To maximise the efficiency and continuously improve operations at the civic amenity facility.	To increase the efficiency of the civic amenity	Investigate the possibility of revising the traffic flow layout of the civic amenity facility	Jerome O'Brien	November 2009
			Continue to monitor and control the site security of the facility through the newly installed CCTV system.	Jerome O'Brien	Ongoing

Objective No.	Objective	Target	Tasks	Person Responsible	Estimated Completion Date
5 (ctd)	To maximise the efficiency and continuously improve operations at the civic amenity facility.	To increase the efficiency of the civic amenity	Introduce handheld devices to log and record customers using the Civic Amenity Facility and types and tonnages of quantities to be disposed / recycled.	Jerome O'Brien	March 2009
6	Review closure modifications of the Waste Licence following the closure of the landfill facility	Reduce the monitoring requirements following closure of the landfill	Carry out a risk assessment on the environmental monitoring results at the facility, to assess if a reduction in the monitoring and reporting regime would be sufficient following the closure of the landfill.	Jerome O'Brien	March 2009
7	Review staffing levels across the organisation to enable a continual service to the public	Ensure minimum staff levels on site to prevent facility closure	Carry out a study of remaining waste facility staff and their demograph to facilitate employer, employee and the public	All	January 2009

It is a reality that the realisation of each and every one of the above objectives is conditional on the current economic climate and on Cork County Council's ability to provide a budget for payment of the supply of services, materials, maintenance and consultation in view of a 10% reduction in operating revenue for 2009. In light of the County Manager's directive to staff of 28th January 2009 regarding the provision of service, strict guidelines have been laid out to supervisory staff in regard to economics, budgets and expenditure.

Cork County Council will attempt to uphold its statutory and regulatory responsibility in as far as it relates to any historic and conventional areas of compliance but cannot give assurance on the resolution of any unforeseen or any circumstances requiring unbudgeted expenditure.

10 RESOURCE CONSUMPTION

10.1 Energy and Resource Consumption

During the reporting period the following were the recorded energy and resources consumption for the landfill. The totals include those of the plant hire firms as well as Cork County Council usage for offices, weighbridge, night lighting, leachate pumps, landfill gas flare and site dumper.

The reliance on fossil fuels reduced greatly in 2008 over 2007 by 28,000 litres of gas oil for plant machinery and by 12,500 kWh of electricity reflecting a decrease in waste activity and an acute awareness of energy economy. The primary usage of electricity was attributed to the site lighting which now has been discontinued with the installation of CCTV security.

Table 10.1 2008

Company	Diesel	Electricity
Lining Technology Ltd	36,960 litres	
Ted Motherway AgriPlant Ltd	20,500 litres	
Cork County Council	1,350 litres	
Cork County Council		Day 64,851 kWh
Cork County Council		Night 38,291 kWh
Totals	58,810 litres	103,142 kWh

11 SUMMARY OF PROCEDURES DEVELOPEE

The summary of procedures, developed during this period of the Waste Licence, is illustrated as follows:

Operational Health & Safety Plan

Environmental Liabilities Risk Assessment

11.1 Operational Health & Safety Plan

The Operational Health and Safety Plan was revised to take account of recent changes in legislation, primarily the Safety Health and Welfare at Work Act, Construction Regulations 2006.

11.2 Environmental Liabilities Risk Assessment

The Environmental Liabilities Risk Assessment first submitted by this facility in October 2004 is being re-assessed at this time for submission to the Agency by the second anniversary of the closure of the landfill, 26th February 2009.

This will signal the emergence of the landfill into the aftercare phase on completion of all elements of the landfill restoration as designed and constructed.

12 REPORTS ON FINANCIAL PROVISION

12.1 Financial Provision under the Licence

Cork County Council has made the necessary provision to ensure that there is adequate funding for the management of East Cork Landfill and Civic Amenity Site.

12.2 Management Structure

Details of Operator

Operator Name:	Cork County Council
Operator Address:	County Hall Carrigrohane Road Cork (021) 4276891
Site Name:	East Cork Landfill
Site Address:	Rossmore Carrigtohill Co. Cork (021) 4533934

Management Structure

Cork County Council has overall responsibility for the management and operation of East Cork Landfill and Civic Amenity Site. The Senior Engineer, Environment, South Division is responsible for the management of municipal waste and waste facilities in the Southern Division. The site manager with responsibility for day to day site operations is a Senior Executive Engineer, who is supported by an Environmental Technician in her roles as deputy manager.

Cork County Council continues to contract Fehily Timoney & Company to provide technical and site engineering support and RPS Group Ltd for scheduled environmental monitoring in accordance with the Waste Licence.

Fehily Timoney & Company have been authorised to assist Cork County Council with the following site related activities:

- Provision of site engineering assistance and support
- Leachate assessment and management
- Landfill gas assessment and management
- Environmental Liabilities Risk Assessment for the entire landfill
- Site management procedures, to incorporate the development of an environmental management system (EMS) and preparation of an annual environmental report (AER); engineering design and document preparation.

RPS Group Ltd are authorised by Cork County Council to assist in environmental monitoring of surface water, groundwater and leachate and interpretation of results.

12.3 Public Consultation

The programme for public consultation has been outlined on pages 40-42 in the six-month report, dated January 2001. The Public File is located in the Waste Management Section on Floor 4, County Hall, Cork. The Site File is maintained at Rossmore in the event of a request for consultation.

12.4 Management and Staffing Structure

	Contact Telephone No.
Senior Engineer: Mr Ted Lucey	(021) 4276891
Landfill & CA Site Manager & *Senior Executive Engineer:* Mr Jerome O'Brien	(021) 4533934
Deputy Landfill Manager & *Executive Engineer:* Mr John Paul O'Neill	(024) 93834
Deputy Landfill Manager & CA Site & *Environmental Technician:* Ms Lisa Collins	(021) 4533934
Deputy CA Site Manager & *Weighbridge Operator* Mr Brian Duggan	(021) 4883936

Appendix A

Slope Stability Report

Appendix B

Water Balance Calculations for East Cork Landfill

1st January – 31st December 2008

Appendix C

Estimation of Cumulative and Annual Landfill Gas Emissions

Appendix D

Meteorological Records for East Cork Landfill

1st January – 31st December 2008

Appendix E

Topographical Survey for East Cork Landfill

January 21st 2009

Appendix F

Ambient Noise Survey 2008

Appendix G

Ecology Monitoring Report

Appendix H

Monitoring of Flare Flue Gas Emissions June & December 2008

Appendix A

Slope Stability Report

2008 SLOPE STABILITY REPORT

EAST CORK LANDFILL, ROSSMORE, CARRIGTOHILL

WASTE LICENCE REGISTER W0022-01

Prepared for:

Cork County Council
Rossmore
Carrigtohill
County Cork

Prepared by:

Fehily Timoney & Company
Core House
Pouladuff Road
Cork

January 2009

2008 SLOPE STABILITY REPORT

EAST CORK LANDFILL, ROSSMORE CARRIGTOHILL

WASTE LICENCE REGISTER W0022-01

User is Responsible for Checking the Revision Status of This Document

Rev. Nr.	Description of Changes	Prepared by:	Checked by:	Approved by:	Date:
0	Issue to Client	GS	JM	PR	05/01/09

Client: Cork County Council

Keywords: Landfill, capping, slope stability

Abstract: Cork County Council requested FTC to carry out a slope stability analysis of the Rossmore Landfill site side slopes to comply with Condition 9.20 of the Waste Licence.

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Appendix A – Drawings

1. INTRODUCTION

1.1. Purpose

This report presents the results of a slope stability assessment carried out for East Cork Landfill at Rossmore, Carrigtwohill, Co. Cork. This is in accordance with Condition 9.20 of the EPA waste licence issued to the site (reference: W0022-01). Section 9 of the licence relates to Environmental Monitoring.

1.2. Site Description

The landfill site is located at Rossmore, Carrigtohill, Co. Cork, adjacent to Rossmore Bay. The site is a former limestone quarry surrounded by agricultural land and intertidal mud flats.

The southern part of the landfill site consists of lined cells numbered 01-10. The eastern side of the landfill (Cells 1-4) is capped and covered by vegetation. Cells 5-10, located to the west of the site, are lined and recently capped. Waste slopes have been raised in a domed profile above the perimeter access road level (approximately 8 to 9 m AOD), to a maximum height of around 22 m AOD.

1.3. Slope Stability Analysis Method

SLOPE/W software of GEO-SLOPE International Ltd. was used to assess the stability of Rossmore Landfill Facility's waste embankments. SLOPE/W is a general software tool for the slope stability analysis of earth structures. It uses the limit equilibrium method of analysis by using the idea of dissecting a potential sliding mass into vertical slices. It assesses the factor of safety for both, moment and force equilibrium based on various methods, including Bishops, Janbu and Morgenstern-Price.

Using this software, it is possible to model complex stratigraphy, highly irregular pore-water pressure conditions, a variety of linear and nonlinear shear strength models, virtually any kind of slip surface shape, concentrated loads and pressure lines. Limit equilibrium formulations based on the method of slices are also applied increasingly to stability analysis of structures such as tieback walls, nail or fabric reinforced slopes, and even the sliding stability of structures subjected to high horizontal loading arising, for example, from ice flows.

Traditionally, the factor of safety is defined as that factor by which the shear strength of the soil must be reduced in order to bring the mass of soil into a state of limiting equilibrium along a selected slip surface. The results of the analysis show the overall stability of the embankment expressed as a factor of safety.

The definition of factor of safety used within SLOPE/W is:

$$F = \frac{\text{Available restoring moment (or forces)}}{\text{Total disturbing moment (or forces)}}$$

1.4. Limitations of Slope Stability Analyses

Updated shear strength parameters for landfill waste have been estimated based on parameters used by Kolsch (1995) and Thomas *et al* (1999).

Leachate in landfills may occur in irregular perched bodies as opposed to interconnected liquid bodies. For the purposes of this analysis a waste body leachate level only has been considered.

1.5. Factors Controlling the Stability of Landfill Slopes

The factors controlling the stability of landfill slopes are:

1. Slope geometry
2. Geology
3. Properties of the landfill wastes
4. Properties of the supporting soil
5. Leachate levels within the waste
6. Groundwater levels in the supporting soil
7. Surcharge.

2. DESIGN CRITERIA

2.1. Slope Geometry

Using the most recent available topographical survey by Focus Surveys Ltd. presented on Drawing No. 00-023_1 Rev ZI, dated June 2008, typical cross-sections through the waste slopes of the site were taken at the locations shown on Drawings 2005-004-02-010 and 011. The three slopes analysed namely, 1 - 1, 2 – 2 & 3 – 3 were identified as the steepest slope locations and are representative of the recently capped slopes located at the western side of the landfill. Slope 4 - 4 was analysed as being representative of the already capped slope along the eastern side of the landfill site.

Slope 1 - 1 is approximately 11 m high, 45 m long and has a maximum slope of 1:3.0 (vertical : horizontal).

Slope 2 - 2 is approximately 12 m high, 45 m long, with a maximum slope of 1:3.0.

Slope 3 - 3 is approximately 12 m high, 50 m long, with a maximum slope of 1:3.3.

Slope 4 - 4 is approximately 12 m high, 45 m long and has a maximum slope of 1:2.4.

Sections through the slopes 1 – 1, 2 – 2, 3 - 3 and 4 – 4 are presented in Figures 3.1 to 3.4.

2.2. Geology

The site is underlain by carboniferous deposits of Waulsortian Limestone and Cork Red Marble. The Waulsortian Limestone comprises calcareous mudstone, wackestones and packstones, many of which contain original cavities filled with internal sediments and cements.

The subsoils in the area have been described as Quaternary sandy clays and minor sand and gravel deposits. They range in thickness from 1 m to 3 m in the central part of the peninsula on which the site is located and up to 24 m towards the east of the site. It is understood that the subsoils have been removed from the central part of the site during quarry excavation.

2.3. Waste Parameters

Table 2.1 below shows the parameters used for the landfill waste materials.

Table 2.1: Shear Strength Parameters for Waste Materials

Material	Waste (Old)	Waste (Fresh)
Cohesion (c')	10 kN/m^2	10 kN/m^2
Effective friction angle (ϕ')	22°	15°
Unit weight γ	11 kN/m^3	9.5 kN/m^3

The Slope 4 – 4 for already capped cells located at the eastern side is considered as consisting of old waste. Slopes 1 – 1, 2 – 2 & 3 – 3 for recently capped cells located at the western side are considered as consisting of fresh waste. These parameters are the typical range of values from published papers on the properties of waste.

2.4. Properties of the supporting materials and capping layer

Table 2.2 below shows typical parameters used for the capping, clay liner and bedrock.

Table 2.2: Shear Strength Parameters for Typical Supporting Materials

Material	Clay Capping	Clay Liner	Bedrock
Cohesion, c', kN/m^2	4	5	Impenetrable
Effective Friction angle, ϕ', °	27	25	
Bulk unit weight, γ, kN/m^3	18	19	

2.5. Leachate levels within the waste material

In practice, the leachate level in the lined cells is maintained at 1 m above the clay liner through pumping from a series of cell pumps. To assess the effects of leachate levels within the waste, analyses was carried out for models simulating the leachate level maintained at 1 m below the toe of the slope as elevation of the clay liner may vary from one section to another.

The leachate levels modelled were as follows:

Slope	Modelled Leachate Level (mAOD)
1 – 1	9.50
2 – 2	9.00
3 – 3	9.00
4 - 4	5.25

2.6. Surcharge

No surcharge loads were used in the analyses of all the Slopes as the landfill is now closed and surcharging above that imposed by grass cutting and other maintenance is not envisaged. Surcharge due to grass cutting machinery etc is not expected to significantly impact on overall stability.

3. RESULTS

3.1. Slope Stability Analyses

Eight models were run at four representative locations to assess the slope stability of the landfill waste embankments. The results of these analyses are summarised in Table 3.1 with factors of safety calculated for Bishop, Janbu and Morgenstern-Price methods. Table 3.1 also gives the slip location of each slope, the waste parameters applied, the leachate level simulated, and the length of the relevant slip.

A typical analysis carried out for each of the slopes is presented in Figures 3.1 - 3.4.

3.2. Factors of Safety

Factors of safety for potential slope failures (Table 3.1) ranged from 1.41 to 2.20. A factor of safety of 1.0 indicates the slope is in equilibrium and on the point of failure. Factors of safety greater than 1.0 indicate a margin of safety against failure. A factor of safety of 1.3 or greater is appropriate for landfill interim side slopes, with this value increasing to 1.5 for final side slopes after capping is complete.

Table 3.1: Slope Analyses Results

Slope name	Waste parameters (C, γ & φ)	Leachate Level (mAOD)	Bishop FoS	Janbu FoS	Morgenstern-Price FoS	Slip Length (m)	Slip location
1 - 1	10, 9.5, 15	9.5	1.73	1.53	1.73	44	Deep slip through waste materials
1 - 1	10, 9.5, 15	9.5	2.20	2.09	2.20	23	Surficial translational slip in middle section in waste material
2 - 2	10, 9.5, 15	9.0	1.62	1.41	1.62	50	Deep slip through waste materials
2 - 2	10, 9.5, 15	9.0	2.00	1.89	2.00	24	Surficial translational slip in middle section in waste material
3 - 3	10, 9.5, 15	9.0	1.77	1.54	1.77	46	Deep slip through waste materials
3 - 3	10, 9.5, 15	9.0	2.06	1.92	2.06	30	Surficial translational slip in lower section in waste material
4 - 4	10, 11, 22	5.25	1.89	1.71	1.89	38	Deep slip through waste materials
4 - 4	10, 11, 22	5.25	2.02	1.89	2.02	28	Surficial translational slip in middle section in waste material

Figure 3.1: Typical plane slope failure for Section 1 – 1 Leachate Level 9.5 mAOD (Morgenstern-Price method)

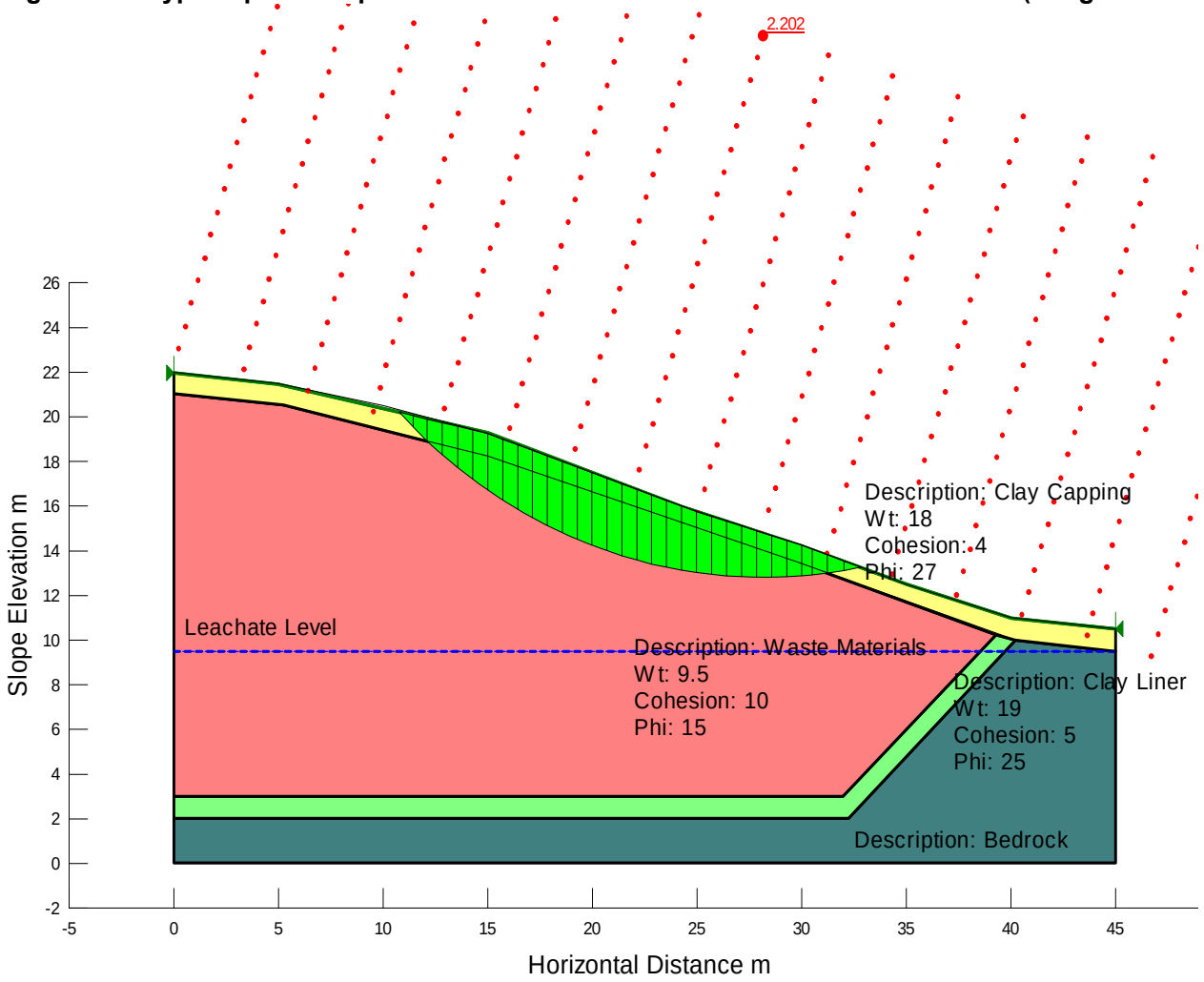


Figure 3.2: Typical deep slope failure for Section 2 – 2 Leachate Level 9 mAOD (Bishop Method)

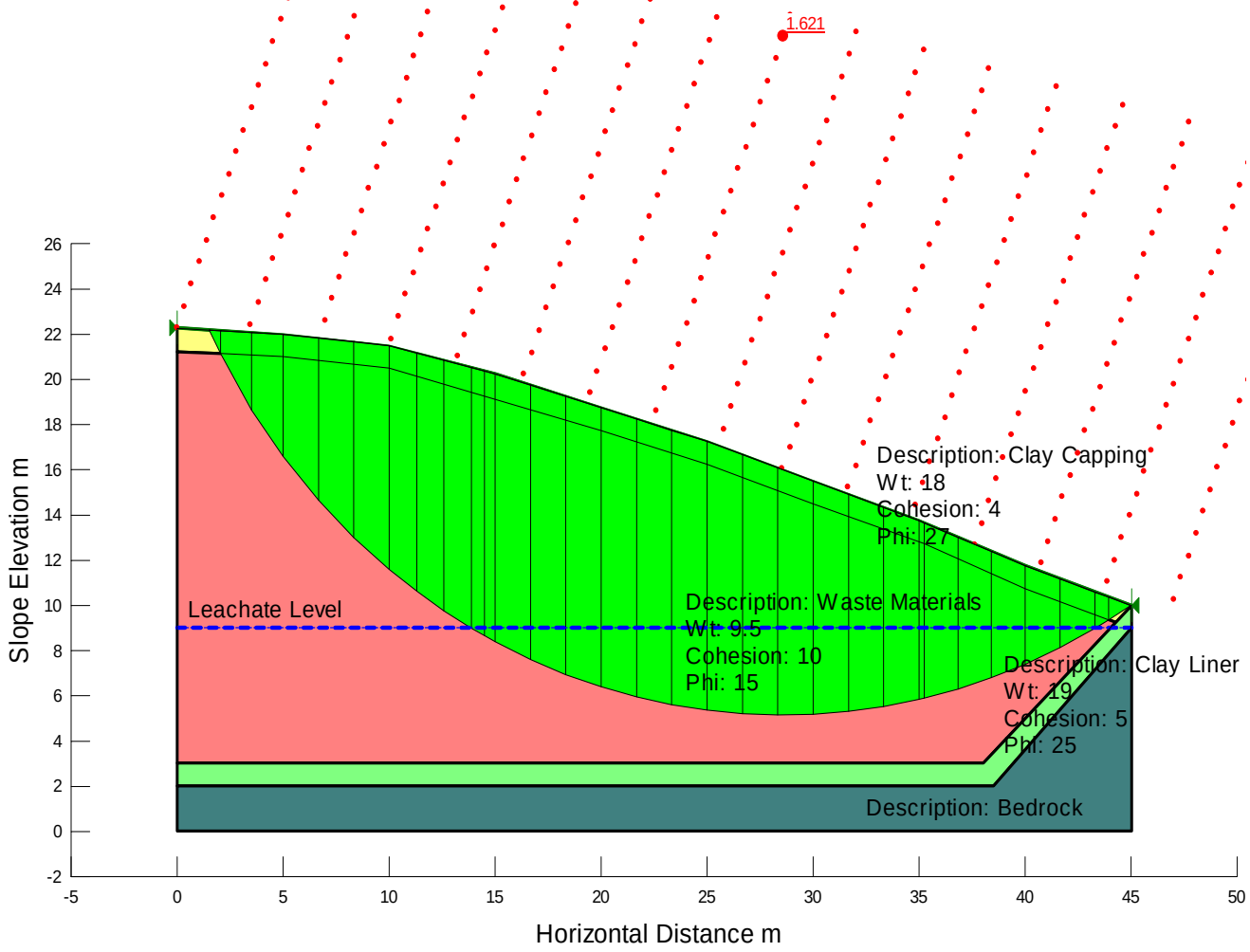


Figure 3.3: Typical deep slope failure for Section 3 – 3 Leachate Level 9 mAOD (Bishop Method).

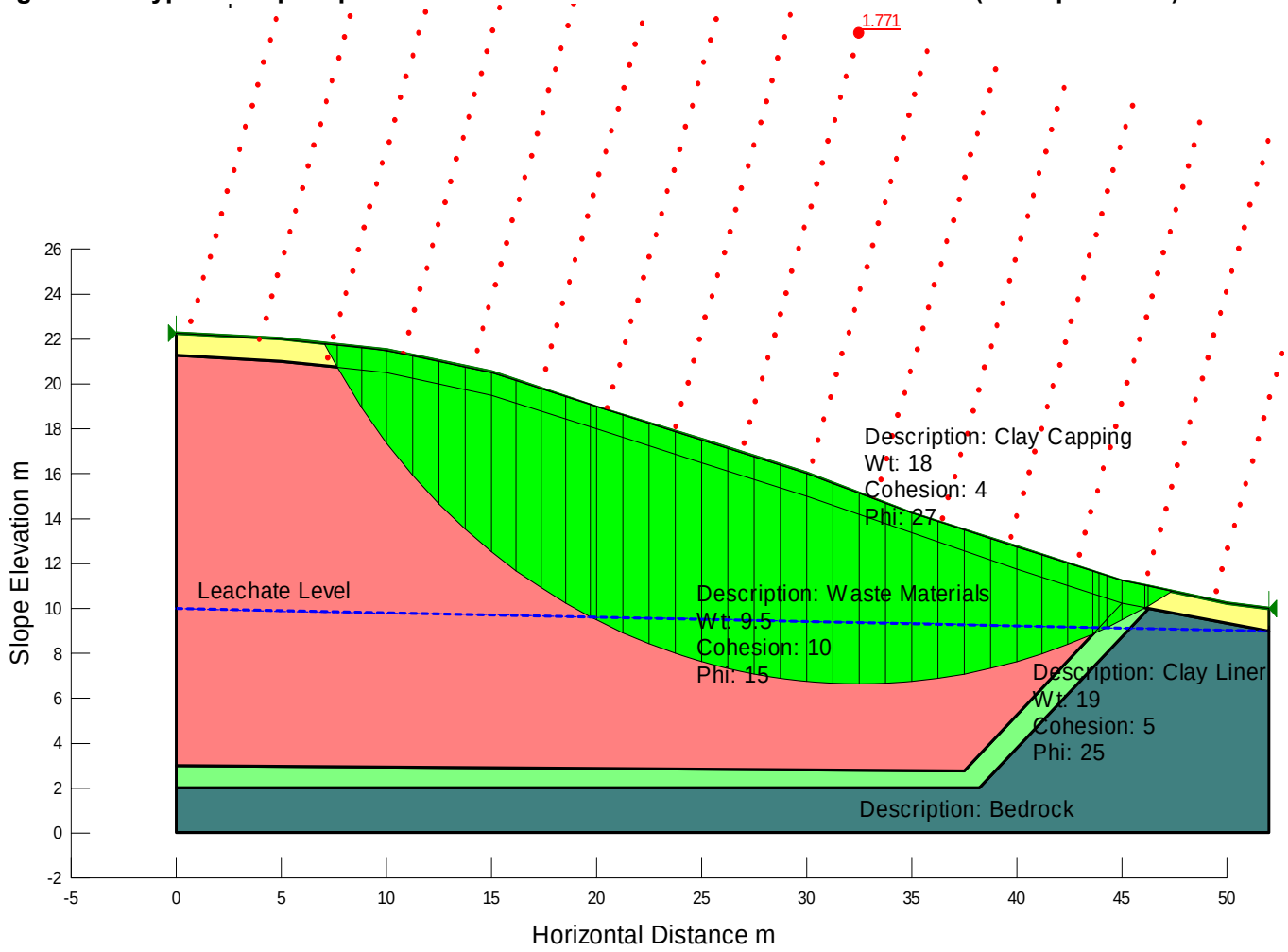
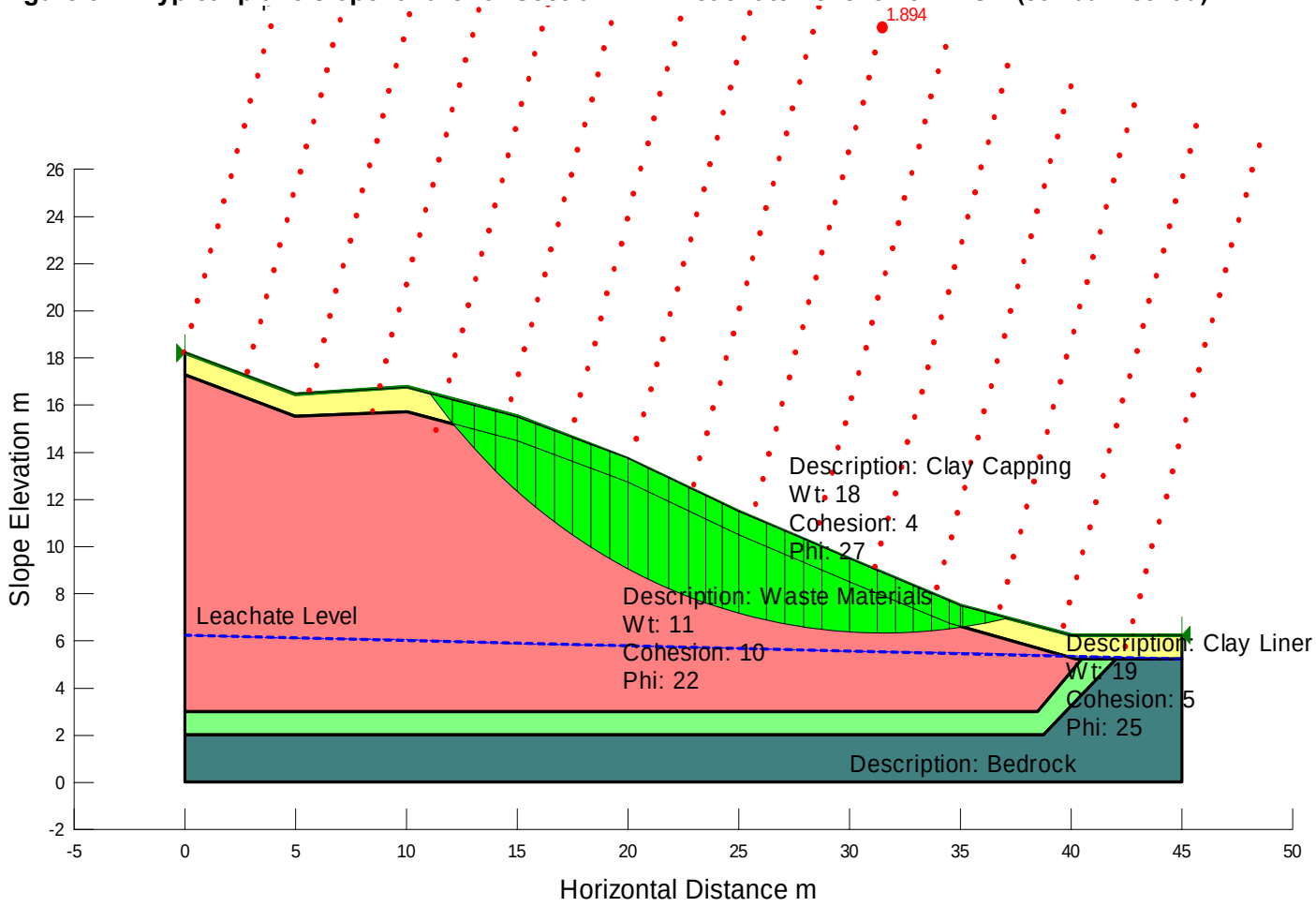


Figure 3.4: Typical plane slope failure for Section 4 – 4 Leachate Level 5.25 mAOD (Janbu Method)



4. DISCUSSIONS AND CONCLUSIONS

Factors of safety for potential slope failures for the four typical slope locations ranged from 1.41 to 2.20. Out of the total 24 factor of safety values calculated for eight case scenarios, all of the factors of safety greater than 1.5 except one that is 1.41.

Factors of safety values against deep-seated failure of the landfill embankment within the waste material ranged from 1.41 to 1.89. The lengths of the potential deep-seated failures are in the range of 38 to 50 m.

Factors of safety for deep-seated failure through both the capping and waste material were obtained along recently capped Slopes 1-1, 2-2 and 3-3 investigated and based on the analyses presented, the landfill side slopes are considered stable. Factors of safety for Slope 4 – 4, taken as a typical example of slopes in Cells 01-04, ranged from 1.71 – 2.02 and is hence considered stable.

To maintain a factor of safety 1.5 or greater, leachate and groundwater levels must be regularly monitored and pumped down to prevent a build up within the waste body and cause potential instability of the landfill slopes.

It will be possible to better control leachate level in Cells 01-10 as the entire area is now permanently capped. Leachate cell pumps have also recently been upgraded and the leachate recirculation system has been extended over Cells 05-10.

5. REFERENCES

1. Kusch (1995) Material values for some mechanical properties of domestic waste, Proceedings 5th Sardinia International Landfill Symposium, Vol 2, pp 711-729.

2. S Thomas, A Aboura, J P Gourc, P Gotteland, H Billard, T Delineau, T Gisbert, J F Ouvry and M Vuillemin, (1999), An in-situ waste mechanical experimentation on a French Landfill, Vol 3, Sardinia Landfill Symposium, pp 445-452.

3. Slope Stability Report (2007). East Cork Landfill, Rossmore, County Cork.

4. Survey Drawing No. 00-023_1 Rev ZI provided by Focus Surveys Ltd., Rossmore Landfill Site, dated 13 June 2008.

Appendix A – Drawings

DRAWINGS 2005-004-02-010 & 2005-004-02-011 Rev A

Topographic Survey showing
Section lines for Slope Stability Analysis

SITE LOCATION MAP

N.T.S.

SECTIONS LOCATION PLAN

Scale 1:1000

0m 5m 10m 15m 20m 25m 30m 35m 40m 45m 50m

Scale 1:1000

NATURAL SCALE 100mm 10 0 10 20 50 100mm

ORIGINAL DRAWING SIZE A1 - (841 x 594)

NOT FOR CONSTRUCTION UNLESS SPECIFICALLY STATED OTHERWISE

Notes:

1. Based On Topographic Site Survey Drawing No. 00-23-01 Rev ZI (25-06-08) Received from Focus Surveys Ltd.
2. Refer to report CCC-RLC_Rpt009-0 2008 Slope Stability for Figures relating to sections;
   Section 1-1 : Figure 3.1
   Section 2-2 : Figure 3.2
   Section 3-3 : Figure 3.3

Rev.	Drawn	Chkd	Apprd		
A	JIM	MM	PC	Cork 05.01.09	ISSUE TO CLIENT
				Rev Origin / Date	Description

Revision History: A

Name of Client

CORK COUNTY COUNCIL

Name of Job

ROSSMORE LICENCE COMPLIANCE

Title of Drawing

2008 SLOPE STABILITY ANALYSIS FOR CAPPED WESTERN SLOPES

Scales Used	This Drawing was printed to
1:1000	A3

Dwg. No.	Rev.
2005-004-02-010	A

O:\ACAD\2005\004-02\CCC-RLC_R10-011.dwg

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SITE LOCATION MAP

N.T.S.

Notes:

1. Based On Topographic Site Survey Drawing No. 00-23-01 Rev 2I (25-06-08) Received from Focus Surveys Ltd.
2. Refer to report CCC-RLC_Rpt009-0 2008 Slope Stability for Figures relating to sections; Section 4-4 : Figure 3.4

SECTION LOCATION PLAN

Scale 1:1000

Scale 1:1000

Rev.	Drawn	Chk'd	Appr'd	Date	Description
A	MW	JM	PC	05.01.09	ISSUE TO CLIENT
Revision History	A			Cork	Rev Origin

Name of Client

CORK COUNTY COUNCIL

Name of Job

ROSSMORE LICENCE COMPLIANCE

Title of Drawing

2008 SLOPE STABILITY ANALYSIS
CAPPED EASTERN SLOPES

Scales Used	This Drawing was printed to
1:1000	A3

Dwg. No.	Rev.
2005-004-02-011	A

O:\ACAD\2005\004-02\CCC-RLC_010-011.dwg

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Appendix B

Water Balance Calculations for East Cork Landfill

1st January – 31st December 2008

CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES

Cork : Tel 021-4964133 Fax 021-4964464

DESIGNED: AR **CHECKED:** JM
DATE: 09/12/08 **REVISION:** 0
JOB NUMBER: 2005-004-02
CALC NUMBER: 2008 Water Balance
C:\Documents and Settings\johnme\Desktop\temp Rossmore Water Balance 2008.xls
FILE
SHEET Calc cover

PROJECT: Regulatory Compliance

DESCRIPTION: Water Balance Calculation For Rossmore Landfill

Rev	Date	Purpose and Description	Prepared	Checked	Reviewed	Approved
0	09-Dec-08	The purpose of this calculation is to complete a water balance calculation for East Cork (Rossmore) Landfill in accordance with the requirements of the waste licence, WL0022-01. The water balance is carried out for the 2008 licence year.	AR	AR	JM	JM

Fehily Timoney Co.
Core House
Pouladuff Rd.
Cork

Ref.		Output

i References

1 EPA Landfill Manual - Landfill Site Design
2 Waste Licence WL022-01
4 Evapotranspiration data January to December 2007 *(see file Q:\2005\004\02\Calculations\Rossmore Water Balances\2008 Water Balance\CCC-RLC_Rainfall 2008.xls)*

5 Volumes of Leachate tankered off Site January to December 2008 *(see Q:\2005-004-02\Calculations\Rossmore Water Balances\CCC-RLC_Leachate totals 2008.xls*
6 Rainfall data January to December 2008 (see file *Q:\2005\004\02\Calculations\Rossmore Water Balances\2008 Water Balance\CCC-RLC_Rainfall 2008.xls*)
7 Records of leachate tankered from Youghal to Rossmore.

ii List of FTC Drawings

iii List of Appendices

Appendix 1 Water Balance

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Ref.

Output

Contents

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1.0 Introduction & Purpose

The purpose of this exercise is to carry out a water balance calculation for East Cork Landfill in accordance with the requirements of waste licence W0022-01. The water balance calculation will be used to predict the total volume of leachate generated at Rossmore Landfill during the 2008 licence year, i.e. January to December 2008. The result of this calculation will be used in the Annual Environmental Report for the site for 2008.

2.0 Design Criteria

The calculation is carried out using MS Excel and following the method from the EPA Manual on Landfill Site Design, ref Section 7.2, page 49. The water balance equation used is:

Ref 1

$$Lo = [ER(A) + LW + IRCA + ER(l)] - a(W);$$

where:

Lo =	leachate produced (m^3)
ER =	effective rainfall, actual rainfall is used for active Cells (m)
A =	area of Cell (m2)
LW =	liquid waste (m^3)
IRCA =	infiltration through restored and capped areas (m^3)
l =	surface area of lagoons (m^2)
a =	absorptive capacity of waste (m^3/t)
W =	weight of waste deposited (t/a)

3.0 Assumptions & Design Inputs

A rainfall infiltration rate of 100% is used for active Cells, 75% is assumed for the temporarily capped areas, and 5% for areas with a permanent cap. An absorptive capacity of 0.07 m^3/t for the waste is used. These figures are in line with EPA guidelines.

Cells 1 to 10 at Rossmore are permanently capped. The volume of leachate tankered off site and the rainfall and evapotranspiration data for Rossmore Landfill were provided by Cork County Council. Weather data recorded at Rossmore Landfill has been used in calculations.

No landfilling took place at Rossmore in 2008.

Ref 4 & 6 The rainfall and evapotranspiration data, as recorded at the on site weather station for 2008 is as follows:

Table 1 - Rainfall and Evapotranspiration data - Provided by Cork County Council

Month	Rainfall (mm)	PE (mm)
Jan-08	140.0	32.9
Feb-08	41.4	30.3
Mar-08	82.6	51.8
Apr-08	26.8	54.0
May-08	86.4	52.0
Jun-08	91.4	68.8
Jul-08	166.2	70.1
Aug-08	115.2	63.5
Sep-08	127.2	58.9
Oct-08	78.2	41.2
Nov-08	54.2	30.9
Dec-08	33.8	22.0

The volume of leachate tankered off site is provided in Table 02 below. Note, in the calculation, it is assumed that 1 m^3 of leachate weighs 1.03 tonnes.

Ref 5

Table 2 - Leachate Tankered Off-Site

Month	(t)	(m^3)
Jan-08	2,173.16	2,109.9
Feb-08	1,298.38	1,260.6
Mar-08	2,276.44	2,210.1
Apr-08	738.70	717.2
May-08	1,004.69	975.4
Jun-08	677.48	657.7
Jul-08	1,329.19	1,290.5
Aug-08	406.07	394.2
Sep-08	612.93	595.1
Oct-08	-	0.0
Nov-08	887.2	861.4
Dec-08	1,381.31	1,341.1
Total	**12,785.6**	**12,413.2**

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Rossmore Landfill is divided up into a number of Cells, the areas of which are given below:

Cell	Area (m^2)
Cell 1	6,089
Cell 2	8,522
Cell 3	6,065
Cell 4	7,726
Cell 5	7,190
Cell 6	5,579
Cell 7	6,300
Cell 8a	5,027
Cell 8b	3,050
Cell 9	6,145
Cell 10	5,042
Total	**66,735**

4.0 Main Body of Calculations

Please Refer to Appendix 1 Water Balance for detailed calculations

4.1 Leachate received from Youghal Landfill

Ref 7 During the month of November 2008, leachate was tankered from Youghal Landfill, to the lagoons at Rossmore Landfill. Volumes transported are presented in the table below.

Date and Time	Leachate Weight (kg)
12-Nov-08 08:37	22,520
12-Nov-08 11:32	23,180
12-Nov-08 14:35	23,540
13-Nov-08 08:17	22,940
13-Nov-08 10:46	23,220
13-Nov-08 14:00	24,120
14-Nov-08 08:12	23,020
14-Nov-08 10:37	23,240
14-Nov-08 14:04	23,240
15-Nov-08 08:36	23,020
15-Nov-08 11:10	23,280
17-Nov-08 08:31	23,660
17-Nov-08 11:51	23,480
17-Nov-08 14:50	23,640
18-Nov-08 08:33	23,280
18-Nov-08 10:46	23,020
18-Nov-08 14:08	23,520
19-Nov-08 08:34	23,720
19-Nov-08 11:24	23,660
19-Nov-08 14:53	23,420
20-Nov-08 08:32	23,540
20-Nov-08 10:43	23,360
20-Nov-08 14:20	23,540
21-Nov-08 08:34	23,140
21-Nov-08 11:21	22,880
21-Nov-08 14:56	22,580
22-Nov-08 08:32	22,800
13-Nov-08 08:36	23,340
13-Nov-08 11:23	24,100
13-Nov-08 14:44	22,480
14-Nov-08 08:13	23,060
14-Nov-08 11:15	23,080
14-Nov-08 14:39	23,360
15-Nov-08 08:34	23,240
15-Nov-08 10:44	23,400
17-Nov-08 08:31	23,740
17-Nov-08 10:59	23,840
17-Nov-08 14:21	23,760
18-Nov-08 08:33	23,660
18-Nov-08 11:22	23,660
18-Nov-08 14:46	23,740

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Ref. Output

Date and Time	Leachate Weight (kg)
19-Nov-08 08:35	23,800
19-Nov-08 10:39	23,640
19-Nov-08 14:20	23,240
20-Nov-08 08:30	23,840
20-Nov-08 11:25	23,280
20-Nov-08 14:51	23,600
21-Nov-08 08:35	23,480
21-Nov-08 10:44	23,100
21-Nov-08 14:21	22,920
22-Nov-08 08:33	23,020
22-Nov-08 10:44	22,940
22-Nov-08 11:32	23,780
Total in kg	**1,237,660**

Expressed in tonnes	1,237.66	tonnes
Expressed in litres	1,213,392.16	litres
Expressed in m3	1,213.39	m3

5.0 Results

App'x 1 As calculated in Appendix 1, the total predicted annual leachate generated at Rossmore Landfill in 2008 is **3,455** m^3

The volume of leachate tankered off site in 2008 (total of Table 3 above) is	12,413	m^3
The volume of leachate tankered from Youghal to Rossmore in November 2008 is	1,213	m^3
Nett volume of leachate tankered offsite for 2008 =	**11,200**	m^3

6.0 Discussion

There is a difference of 7,745 m^3 between the volume of leachate tankered from the site and the volume calculated. Some of this difference can be explained between the months of January and April 2008, before the landfill was completely capped. During this time, although rainfall incident on a capped area would not have infiltrated in the area where it landed, it would have drained to the edge of the lined area and percolated into the waste body. This would caused an increase in the leachate volume caused because of rainfall.

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Water Balance Calculation for Rossmore Landfill Facility

Month	Rainfall	Potential Evapotran-spiration (P.E.)	Effective Rainfall	Waste Input	Active Cells	Temporarily Capped Cells	Permanently Restored Cells	Active Area	Temporarily Capped Cells	Permanently Restored Cells	Infiltration		
											Active	Temp Capped Cells	Permanently Restored Cells
	(mm)	(mm)	(mm)	(tonnes)				(m^2)	(m^2)	(m^2)	(m^3)	(m^3)	(m^3)
Jan-08	140.00	32.9	107.1	0	-	See Note 01 below		0	15,766	50,969	0	1,266	273
Feb-08	41.40	30.3	11.1	0	-	See Note 01 below		0	11,103	55,632	0	92	31
Mar-08	82.60	51.8	30.8	0	-	See Note 01 below		0	4,542	62,193	0	105	96
Apr-08	26.80	54.0	0.0	0	-	See Note 01 below		0	3,229	63,506	0	0	0
May-08	86.40	52.0	34.4	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	115
Jun-08	91.40	68.8	22.6	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	75
Jul-08	166.20	70.1	96.1	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	321
Aug-08	115.20	63.5	51.7	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	173
Sep-08	127.20	58.9	68.3	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	228
Oct-08	78.20	41.2	37.0	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	123
Nov-08	54.20	30.9	23.3	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	78
Dec-08	33.80	22.0	11.8	0	-	-	1,2,3,4,5,6,7,8,9,10	0	0	66,735	0	0	39
Total	**1,043**	**576**	**494**	**0**							**0**	**1,464**	**1,551**

Infiltration rates (%)	
Active Area	100
Temp. Covered Area	75
Permanently Capped Area	5

† Absorptive Capacity (m^3/tonne) 0.07

Area of leachate lagoons = 1,135 m^2

Note 01 - The areas of capping for each month from January to May were recorded on site, but it is unclear what order cells were capped in.

Month	Liquid Waste	Lagoon Contribution	Absorptive Capacity† of the waste	Leachate			Total Predicted Leachate	Cumulative Predicted Leachate	Leachate Tankered Off-Site		Deficit
				Active Cells	Temporarily Capped Cells	Permanently Restored Cells					
	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(t)	(m^3)	(m^3)
Jan-08	0	0	0	0	1,266	273	1,539	1,539	2,173	2,110	-571
Feb-08	0	13	0	0	92	31	136	1,675	1,298	1,261	-1,125
Mar-08	0	35	0	0	105	96	236	1,911	2,276	2,210	-1,974
Apr-08	0	0	0	0	0	0	0	1,911	739	717	-717
May-08	0	39	0	0	0	115	154	2,065	1,005	975	-822
Jun-08	0	26	0	0	0	75	101	2,166	677	658	-557
Jul-08	0	109	0	0	0	321	430	2,596	1,329	1,290	-861
Aug-08	0	59	0	0	0	173	231	2,827	406	394	-163
Sep-08	0	78	0	0	0	228	305	3,132	613	595	-290
Oct-08	0	42	0	0	0	123	165	3,298	0	0	165
Nov-08	0	26	0	0	0	78	104	3,402	887	861	-757
Dec-08	0	13	0	0	0	39	53	3,455	1,381	1,341	-1,288
Total	**0**	**439**	**0**	**0**	**1,464**	**1,551**	**3,455**		**12,786**	**12,413**	**-8,959**

Appendix C

Estimation of Cumulative and Annual Landfill Gas Emissions

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DESIGNED: AR **CHECKED:** JM
DATE: 20/01/09 **REVISION:** 1
JOB NUMBER: **2005-004-02**
CALC NUMBER:
FILE \\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Mo
SHEET Calc cover

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Rev	Date	Purpose and Description	Prepared	Checked	Reviewed	Approved
0	09-Dec-08	The purpose of this calculation is to present two gas production model for East Cork (Rossmore) Landfill, prepared using GasSim Lite version 1.5 from Golder Associates (UK) Ltd. and LandGEM from the US EPA. This calculation and its results will be submitted with the 2008 AER for the site in accordance with the requirements of the waste licence, WL002201.	AR			
1	20-Jan-09	Revision of model to use inventory defaults for LandGEM model	AR	JM		

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DATE:	**20/01/09**	**REVISION:**	
JOB NUMBER:		**2005-004-02**	
CALC NUMBER:		**0**	
FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models		
SHEET	Check Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Description of Calculations **Page 2 of 11**

1.0 GENERAL – Review See note 1

A constructability review has been carried out
Functionality issues have been addressed
Health and Safety issues have been reviewed
Planning, Waste License and fire safety issues have been addressed

2.0 DRAWINGS, REPORTS

All drawings & reports have been signed, checked and approved
Drawings & reports have been cross-checked against design information / calculations

3.0 ELECTRONIC CALCULATIONS ONLY

The software used is on the list of approved software
The printout is identified with the software title and version
Is the input information selected suitable
Has required output information been suitably assessed
The output data files are held in the appropriate storage area HARD COPY

4.0 CALCULATIONS

Assumptions are realistic
Calculations comply with the inputs, appropriate codes and standards
Standards, codes and other regulatory documents are appropriately referenced in the calculations
Sources of information are referenced and attached where appropriate
The range of pages in question are identified and marked with the date
Calculations comply with the project brief/inputs
The lead page is signed and dated by the designer.
All tasks associated with this calculation signed off (see Task Manager)
Calculation review by peer
All electronic calculations have path, file name on each hard copy sheet

5.0 OPPORTUNITIES FOR IMPROVEMENT

The checker must sign here to confirm that any learning points or useful feedback have been entered in the task management database as a “KNOWLEDGE” item.
The checker must sign here to confirm that, If applicable, the above information has been emailed to the Senior CAD Technician or other relevant personnel to ensure that standard design

Checked By JM Date: 27-01-2009

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DESIGNED:	AR	**CHECKED:**	JM
DATE:	20.1.09	**REVISION:**	1
JOB NUMBER:	2005-004-02		
CALC NUMBER:	0		
FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models 2008 rev 1 9-12-08.xls		
SHEET	Calc Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Ref.

Output

i References

1 GasSim Lite version 1.5
2 FTC Calculation: CCC-RLC Rossmore Water Balance 2007 (see *Q:\2005\004\02\Calculations\Rossmore Gas Models\2007 Gas Model)*
3 Waste Tonnages January to December 2007 *(see Q:\2005-004-02\Incoming\07 - Jan-Dec'07 Waste Data.xls*
4 Waste Tonnages January to December 2006 *(see Q:\2005-004-02\Calculations\Water Balance\Incoming\Rossmore Waste Deposited Jan 06 - Dec 06.xls)*
5 Waste Tonnages January to December 2005 (see *Q:\2005-004-02\Calculations\Water Balance\Water Balance info from CCC\CCC-RLC_waste tonnages January to December 2005.xls)*
6 2006 Gas Model *(see Q:\2005\004\02\Calculations\Rossmore Gas Models\2006 Gas Model\CCC-RLC gas model rev2.xls)*
7 Gas utilisation report *(see Q:\2006\004\01\Reports\CCC-LGU_Rpt 001_C.doc)*
8 Gas utilisation model calculation *(see Q:\2006\004\01\Calculations\CCC-LGU_Gas Model rev 3.xls)*
9 2007 Gas Model (*see Q:\2005\004\02\Calculations\Rossmore Gas Models\2007 Gas Model_)*
10 LandGEM-v302-guide by US EPA

ii List of FTC Drawings

iii List of Appendices

App A - GasSim Outputs (graphically)
App B - GasSim Outputs (tabular summary)
App C - LandGem Outputs, Inventory
Chart 1 - LandGem Outputs, Inventory
Chart 2 - Comparison of Results (CH4)
Chart 3 - Comparison of Results (LFG)

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Ref.

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ii List of Drawings
iii List of Appendices

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CALC NUMBER:	0		
FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models 2008 rev 1 9-12-08.xls		
SHEET	Calc Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Ref. | Output

1.0 Introduction & Purpose

The purpose of this Calc Set is to present previously prepared Landfill Gas Prediction Models for Rossmore Landfill for inclusion in the 2008 AER. As no waste was deposited at Rossmore since the 2007 model, the inputs and outputs from that model will not change. The models prepared in 2007 were developed using both the Golder Associates software package, GasSim Lite 1.5, and the US EPA package, LandGEM v3.02.

2.0 Input Data

Opening Year: 1995
Closure Year: Feb-07

2.1 Waste input data:

2,3,4,5 The waste input data for the site is as shown below. These figures come from communications with Cork County Council, and from previous calculations carried out by FTC.

Year	Input Units (t/year)
1995	28,000
1996	29,801
1997	20,476
1998	37,837
1999	34,763
2000	52,000
2001	63,303
2002	82,679
2003	71,708
2004	55,715
2005	31,527
2006	43,115
2007	4,265

Ref 01 **2.2 GasSim Model Details**

Ref 01 **2.2.1 Background**

GasSim is a UK based software package for investigating the gas production from landfills.

Ref 01 **2.2.2 Assumptions**

GasSim makes the following general assumptions (among others):
- the model operates at steady state with a minimum time period of 1 year;
- migration of gas is not modelled in the saturated zone;
- the model does not determine the pressure generated by the landfill and to simplify the model pressure has been excluded from all modules;

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2.2.3 Comments on model

This model uses rainfall data for the UK and while Irish rainfall data may be broadly similar it is not a true reflection of the situation. This is a possible source of error in this model which will need to be taken into account in considering inaccuracies.

This calculation set focuses on the Total Landfill Gas emissions from the landfill site and does not consider what proportion of these gases has been captured by the gas collection network and burnt at the flare

2.2.4 Input justification

The following is a summary of justifications for parameters inputted to the GasSim model.

Infiltration	Default Value of 50mm/yr with a standard deviation of 5mm
Waste Input - tonnages	Based on communication with Landfill maager
Waste Breakdown	90% domestic, 5% civic amenity, 5% sewage sludge
Waste Composition	1980-2010 waste stream from software
% Waste in Place Capped	Area of Cell 1,2,3,4 (28402m2) divided by the total area of the landfill (66735m2)
C02%	Default Value
CH4%	Default Value
Cellulose Decay Rates	Default Value
Moisture Content	Not Justified
Waste Density	Default Value
Leachate Head	Default Value
Hydraulic Conductivity	Default Value
Trace Gas Concentration	Default Value
Trace Gas Molecular Ratios	Default Value
Trace Gas Cap Half-Life	Default Value
Landfill Geometry	Based on drawing no. 2006-004-01-008 total area (66735m2)
Biological Methane Oxidation	Default Value
Cap Thickness	Based on construction detail drawings
Cap Hydraulic Conductivity	Based on details in spec
Liner Thickness	Based on construction detail drawings
Liner Hydraulic Conductivity	Based on details in spec

Ref.		Output
	Page 7 of 11	
10	**2.3 LandGEM Model Parameters**	
10	**2.3.1 Methane Generation Rate (k)**	
	The Methane Generation Rate, k, determines the rate of methane generation for the mass of waste in the landfill. The higher the value of k, the faster the methane generation rate increases and then decays over time. The value of k is primarily a function of four factors: • Moisture content of the waste mass, • Availability of the nutrients for micro organisms that break down the waste to form methane and carbon dioxide • pH of the waste mass, and • Temperature of the waste mass. The k value as it is used in the first-order decomposition rate equation, is in units of 1/year, or year$^{-1.}$ There are 5 k values given as options in LandGEM. The default k value is the CAA k value for conventional landfills.	
10	**2.3.2 Potential Methane Generation Capacity (Lo)**	
	The Potential Methane Generation Capacity, Lo, depends only on the type and composition of waste placed in the landfill. The higher the cellulose content of the waste, the higher the value of Lo. The default Lo values used by LandGEM are representative of MSW. The Lo value, as it is used in the first-order decomposition rate equation, is measured in metric units of cubic metres per megagram to be consistent with the CAA. The default Lo value is the CAA Lo value for conventional landfills.	
10	**2.3.3 Non-methane Organic Compound Concentration**	
	The NMOC Concentration in landfill gas is a function of the types of waste in the landfill and the extent of the reaction that produce various compounds from the anaerobic decomposition of waste. NMOC concentration is measured in units of parts per million by volume (ppmv) and is used by LandGEM only when NMOC emissions are being estimated. The NMOC concentration for the CAA default is 4,000 ppmv as hexane. The NMOC Concentration for the Inventory default is 600 ppmv where co-disposal of hazardous waste has either not occurred or is unknown and 2,400 ppmv where co-disposal of hazardous waste has occurred. The default NMOC concentration is the CAA value. If you use a site-specific value for NMOC concentration, then you must correct for air infiltration.	

10 **2.3.4 Methane Content**

For LandGEM, landfill gas is assumed to be 50 percent methane and 50 percent carbon dioxide, with additional, trace constituents of NMOC's and other air pollutants. When using LandGEM for complying with the CAA, methane content must remain fixed at 50 percent by volume (the model default value).

You may choose other methane amounts for the methane content using the User-specified selection if data exist to support using another concentration. However, using LandGEM at landfills that have methane content outside the range 40 to 60 percent is not recommended. The first-order decomposition rate equation used by LandGEM to determine emissions may not be valid outside this range.

The production of methane is determined using the first-order decomposition rate equation and is not affected by the concentration of methane. However, the concentration of methane affects the calculated production of carbon dioxide. The production of carbon dioxide (Q_{CO2}) is calculated from the production of methane (Q_{CH4} and the methane content percentage (P_{CH4}) using the equation:

$$Q_{CO2} = Q_{CH4} \times \left\{\left[1/\left(P_{CH4}/100\right)\right] - 1\right\}$$

This equation is derived as follows:

$$Q_{total} = Q_{CH4} + Q_{CO2}$$
$$Q_{CH4} = Q_{total} \times \left(P_{CH4}/100\right)$$
$$Q_{CO2} = Q_{total} - Q_{CH4} = \left[Q_{CH4}/\left(P_{CH4}/100\right)\right] - Q_{CH4}$$
$$Q_{CO2} = Q_{CH4} \times \left\{\left[1/\left(P_{CH4}/100\right)\right] - 1\right\}$$

where Q_{total} is the total production of landfill gas.

2.3.5 CAA & Inventory Parameters

LandGEM contains two sets of default parameters:

CAA Defaults—The CAA defaults are based on requirements for MSW landfills laid out by the US Clean Air Act (CAA), including the NSPS/EG and NESHAP. This set of default parameters yields conservative emission estimates and can be used for determining whether a landfill is subject to the control requirements of the NSPS/EG or NESHAP.

Inventory Defaults—With the exception of wet landfill defaults, the inventory defaults are based on emission factors in the U.S. Environmental Protection Agency's (EPA) Compilation of Air Pollutant Emission Factors (AP-42). This set of defaults yields average emissions and can be used to generate emission estimates for use in emission inventories and air permits in the absence of site-specific test data.

2.3.6 Site Specific Parameters

Where site specific data is available for the actual quantities of gas produced, the model can be calibrated by varying the parameters to match the predicted volumes to the actual volumes as closely as possible.

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DATE:	20.1.09	**REVISION:**	1
JOB NUMBER:	2005-004-02		
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FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models 2008 rev 1 9-12-08.xls		
SHEET	Calc Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Ref. | Output

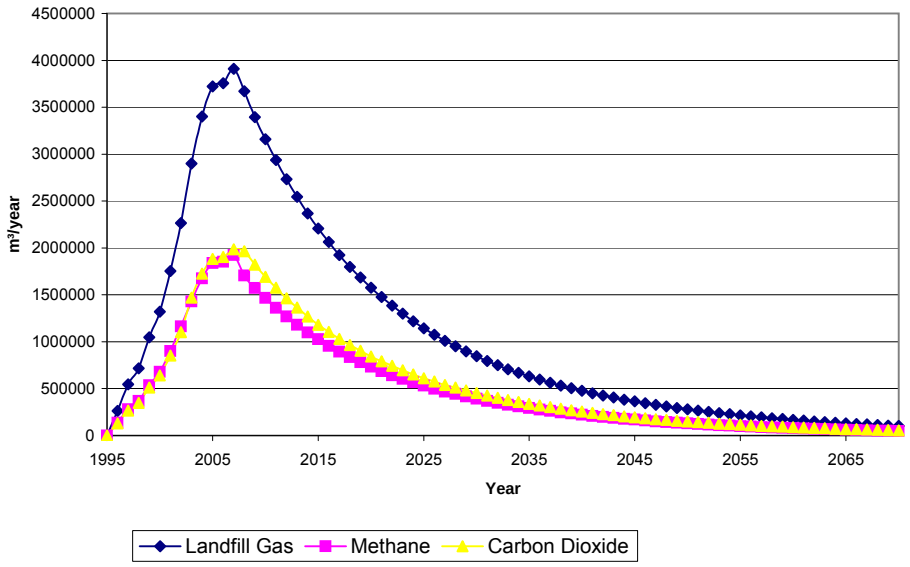
3.0 GasSim Calculations

A simulation using the GasSIM model was carried out to predict the volumes of gas arising from the landfill. The modelled outputs from the simulation are outlined below

App A **3.1 "CCC-RLC 2007 GasSim Lite 1.5"**

6,7 MODEL PARAMETERS (See Section 2.4 above)

Predicted Gas Volumes using GasSim Lite 1.5



Peak Production Year: 2007

Peak Volumes during Peak Production Year:	3,910,548 m^3 landfill gas	446 m^3/hr
	1,925,700 m^3 methane	220 m^3/hr
	1,984,848 m^3 carbon dioxide	227 m^3/hr

For 2008 these volumes become:

419 m^3/hr landfill gas
195 m^3/hr methane

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DESIGNED:	AR	**CHECKED:**	JM
DATE:	20.1.09	**REVISION:**	1
JOB NUMBER:	2005-004-02		
CALC NUMBER:	0		
FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models 2008 rev 1 9-12-08.xls		
SHEET	Calc Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Ref. | Output

4.0 LandGEM Calculations

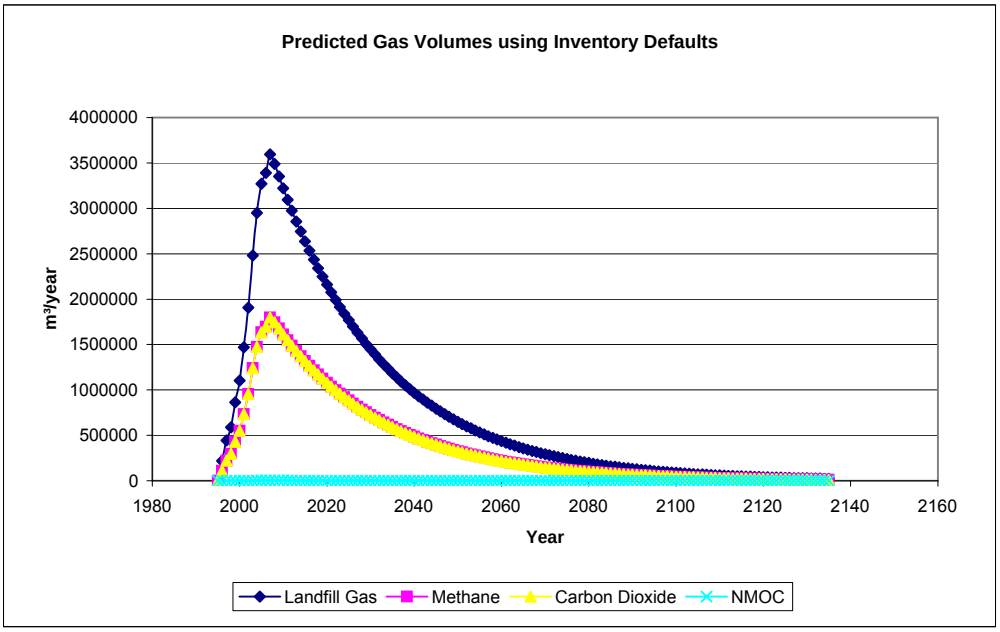
The calculation carried out in LandGEM uses Inventory specific parameters as explained previously.

4.1 "CCC-RLC 2007 Inventory Defaults LandGEM-v302"

MODEL PARAMETERS

Methane Generation Rate, k	0.04	$year^{-1}$
Potential Methane Generation Capacity, Lo	100	m^3/Mg
NMOC Concentration	600	ppmv as hexane
Methane Content	50	% by volume

App D



Peak Production Year:	**2007**		
Peak Volumes:	3,596,260	m^3 landfill gas	411 m^3/hr
	1,798,130	m^3 methane	205 m^3/hr
	1,798,130	m^3 carbon dioxide	
	2,158	m^3 NMOC	

These figures give an indication of the volumes of gas likely to be produced based on average production values.

For 2008 these figures become: 398 m^3/hr landfill gas; 199 m^3/hr methane

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DESIGNED:	AR	**CHECKED:**	JM
DATE:	20.1.09	**REVISION:**	1
JOB NUMBER:	2005-004-02		
CALC NUMBER:	0		
FILE	\\ftc05dr\RCP\2005\004\02\Calculations\Rossmore Gas Models\2008 Gas Model\CCC-RLC_Landfill Gas Models 2008 rev 1 9-12-08.xls		
SHEET	Calc Sheet		

PROJECT: **Regulatory Compliance - Rossmore Landfill**

DESCRIPTION: **GasSim Gas Production Model for Rossmore Landfill**

Ref.

Output

5.0 Discussion

The maximum predicted hourly production volume of landfill gas using the GasSim model is 446 m³/hr, occuring in 2007, which equates to 3,910,548 m³ for the year of 2007. For 2008, this falls to 3,669,846 m³ (i.e. 418 m³/hr). These values reflect the theoretical gas volume available for utilisation at Rossmore.

Using the Inventory default parameters for the LandGem model, outputs a similar production level of landfill gas, with a peak in annual production 2007 of just under 3.6 million m^3 of gas (411 m^3/hr, of which 205 m^3/hr is methane). For 2008, this falls to 398 m³/hr (3,486,480 m³ for the entire year).

These predictions correspond relatively well with the reported flaring rates on site of approximately 425 m³/hr, or approximately 3,723,000 m³/year for 2008.

However, it should be noted that it is likely that the actual gas production from the landfill site is somewhat higher than these levels, as collection efficiencies and methane concentrations are not fully taken account of in these calculations.

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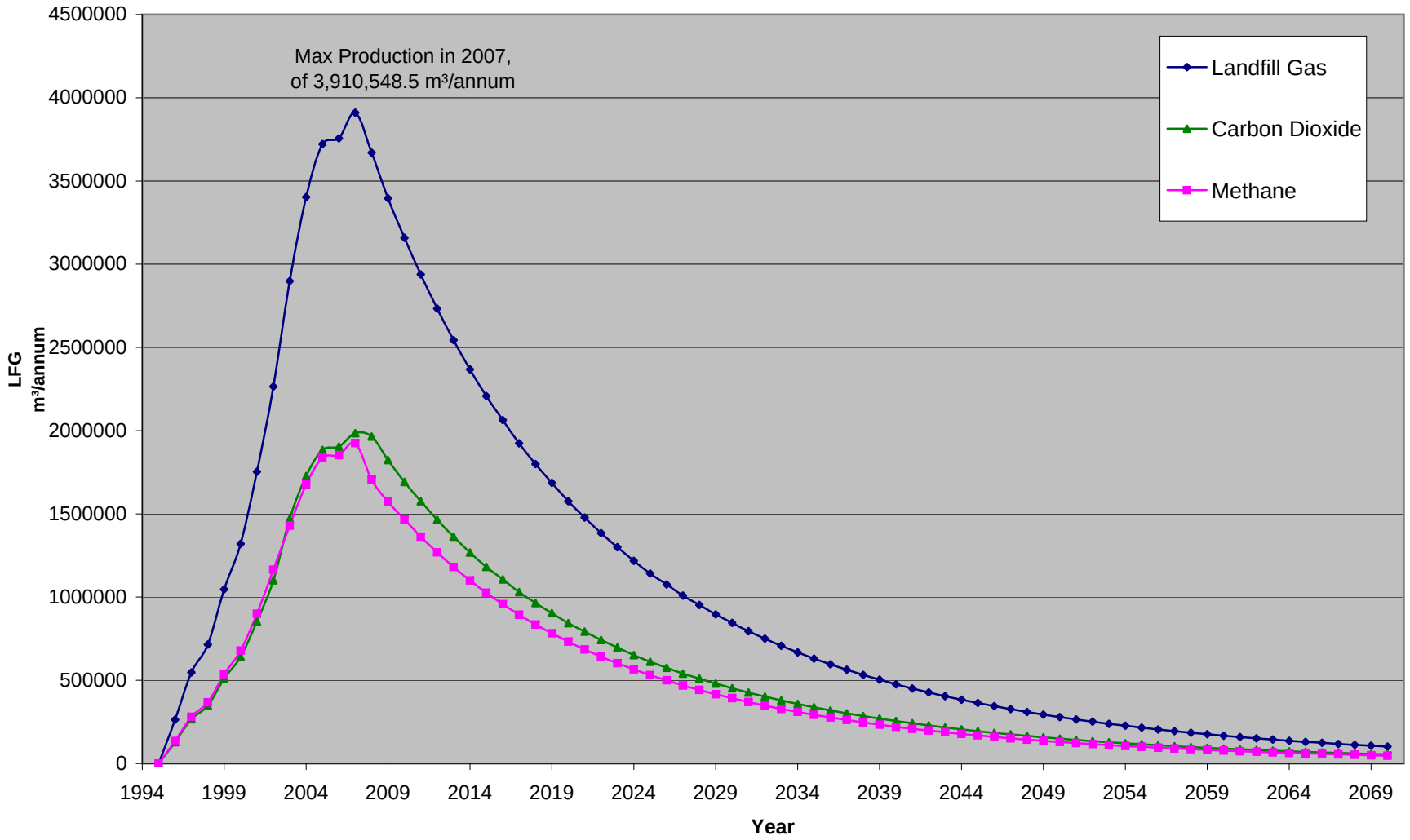
Appendix A - Rossmore Landfill, GasSim Model Outputs



Appendix B - GasSim Model Outputs

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carbon Dioxide - 'chemical'	0	254	527	688	1,010.00	1,270.00	1,690.00	2,180.00	2,910.00	3,420.00	3,730.00	3,770.00	3,930.00	3,890.00	3,610.00
Carbon Dioxide (m^3/hr)	0	128282.828	266161.616	347474.747	510101.0101	641414.1414	853535.3535	1101010.101	1469696.97	1727272.727	1883838.384	1904040.404	1984848.485	1964646.46	1823232.32
Methane (t)	0	91.9	191	250	365	462	612	792	972	1,140.00	1,250.00	1,260.00	1,310.00	1,160.00	1,070.00
Methane (m^3)	0	135093	280770	367500	536550	679140	899640	1164240	1428840	1675800	1837500	1852200	1925700	1705200	1572900
Methane (m^3/hr)	0	15.4215753	32.0513699	41.9520548	61.25	77.52739726	102.6986301	132.9041096	163.109589	191.3013699	209.760274	211.4383562	219.8287671	194.657534	179.554795
CO2 & Methane (LFG - m^3)	0	263375.8	546931.6	714974.7	1046651	1320554.1	1753175.4	2265250.1	2898537	3403072.7	3721338.4	3756240.4	3910548.5	3669846	3396132
CO2 & Methane (LFG - m^3/hr)	0	30.06573	62.43512	81.61812	119.48071	150.74819	200.13417	258.59019	330.88322	388.47862	424.81032	428.79457	446.40964	418.9322	387.6863

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Carbon Dioxide - 'chemical'	3350	3120	2900	2700	2510	2340	2190	2040	1910	1790	1670	1570	1470	1380	1290
Carbon Dioxide (m^3/hr)	1691919	1575758	1464646	1363636	1267676.8	1181818.2	1106060.6	1030303	964646.46	904040.4	843434.34	792929.29	742424.24	696969.7	651515.2
Methane (t)	998	927	863	803	748	698	651	608	568	532	498	466	437	410	385
Methane (m^3)	1467060	1362690	1268610	1180410	1099560	1026060	956970	893760	834960	782040	732060	685020	642390	602700	565950
Methane (m^3/hr)	167.472603	155.558219	144.818493	134.75	125.5205479	117.130137	109.2431507	102.0273973	95.31506849	89.2739726	83.56849315	78.19863014	73.33219178	68.8013699	64.6061644
CO2 & Methane (LFG - m^3)	3158979	2938448	2733256	2544046	2367236.8	2207878.2	2063030.6	1924063	1799606.5	1686080.4	1575494.3	1477949.3	1384814.2	1299670	1217465
CO2 & Methane (LFG - m^3/hr)	360.6141	335.4392	312.0156	290.4163	270.23251	252.04089	235.50578	219.6419	205.43453	192.47493	179.85095	168.71567	158.08382	148.3641	138.98

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Carbon Dioxide - 'chemical'	1210	1140	1070	1010	951	896	844	796	751	709	669	632	598	565	535
Carbon Dioxide (m^3/hr)	611111.1	575757.6	540404	510101	480303.0303	452525.2525	426262.6263	402020.202	379292.9293	358080.8081	337878.7879	319191.9192	302020.202	285353.535	270202.02
Methane (t)	361	340	319	301	283	267	251	237	223	211	199	188	178	168	159
Methane (m^3)	530670	499800	468930	442470	416010	392490	368970	348390	327810	310170	292530	276360	261660	246960	233730
Methane (m^3/hr)	60.5787671	57.0547945	53.5308219	50.510274	47.48972603	44.80479452	42.11986301	39.77054795	37.42123288	35.40753425	33.39383562	31.54794521	29.86986301	28.1917808	26.6815068
CO2 & Methane (LFG - m^3)	1141781	1075558	1009334	952571	896313.03	845015.25	795232.63	750410.2	707102.93	668250.81	630408.79	595551.92	563680.2	532313.5	503932
CO2 & Methane (LFG - m^3/hr)	130.3403	122.7805	115.2208	108.741	102.31884	96.462928	90.77998	85.663265	80.719512	76.284339	71.964474	67.985379	64.347055	60.76639	57.52649

	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054
Carbon Dioxide - 'chemical'	506	479	453	429	407	385	365	347	329	312	296	281	267	253	241
Carbon Dioxide (m^3/hr)	255555.556	241919.192	228787.879	216666.667	205555.5556	194444.4444	184343.4343	175252.5253	166161.6162	157575.7576	149494.9495	141919.1919	134848.4848	127777.778	121717.172
Methane (t)	150	142	135	128	121	115	109	103	97.8	92.8	88.1	83.6	79.4	75.4	71.6
Methane (m^3)	220500	208740	198450	188160	177870	169050	160230	151410	143766	136416	129507	122892	116718	110838	105252
Methane (m^3/hr)	25.1712329	23.8287671	22.6541096	21.4794521	20.30479452	19.29794521	18.29109589	17.28424658	16.41164384	15.57260274	14.78390411	14.02876712	13.3239726	12.6527397	12.0150685
CO2 & Methane (LFG - m^3)	476055.6	450659.2	427237.9	404826.7	383425.56	363494.44	344573.43	326662.53	309927.62	293991.76	279001.95	264811.19	251566.48	238615.8	226969.2
CO2 & Methane (LFG - m^3/hr)	54.34424	51.44511	48.77145	46.21309	43.770041	41.4948	39.334867	37.290243	35.379865	33.560703	31.849538	30.229588	28.717635	27.23924	25.90972

	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069
Carbon Dioxide - 'chemical'	229	217	206	196	187	177	169	161	153	145	138	132	125	119	114
Carbon Dioxide (m^3/hr)	115656.566	109595.96	104040.404	98989.899	94444.44444	89393.93939	85353.53535	81313.13131	77272.72727	73232.32323	69696.9697	66666.66667	63131.31313	60101.0101	57575.7576
Methane (t)	68	64.6	61.4	58.4	55.5	52.8	50.2	47.8	45.4	43.2	41.1	39.2	37.3	35.5	33.8
Methane (m^3)	99960	94962	90258	85848	81585	77616	73794	70266	66738	63504	60417	57624	54831	52185	49686
Methane (m^3/hr)	11.4109589	10.840411	10.3034247	9.8	9.313356164	8.860273973	8.423972603	8.021232877	7.618493151	7.249315068	6.896917808	6.578082192	6.259246575	5.95719178	5.67191781
CO2 & Methane (LFG - m^3)	215616.6	204558	194298.4	184837.9	176029.44	167009.94	159147.54	151579.13	144010.73	136736.32	130113.97	124290.67	117962.31	112286	107261.8
CO2 & Methane (LFG - m^3/hr)	24.61376	23.35137	22.18018	21.10022	20.094685	19.065062	18.167527	17.303554	16.439581	15.609169	14.853193	14.188432	13.466017	12.81804	12.24449

	2070
Carbon Dioxide - 'chemical'	108
Carbon Dioxide (m^3/hr)	54545.4545
Methane (t)	32.2
Methane (m^3)	47334

Methane (m³/hr)	5.40342466
CO2 & Methane (LFG - m³)	101879.5
CO2 & Methane (LFG - m³/hr)	11.63007

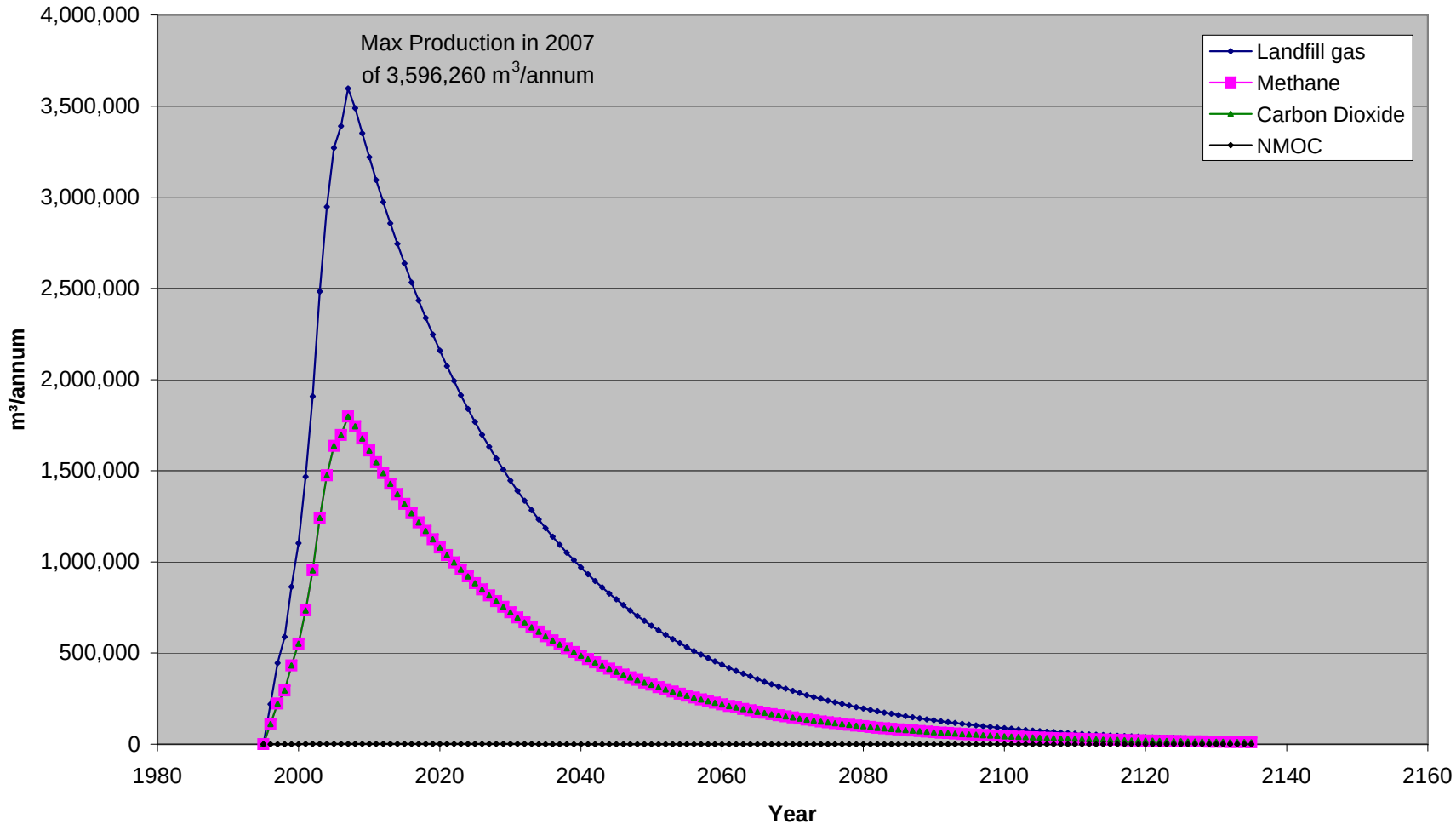
Appendix C - Gas Generation Model Outputs using LandGEM Inventory Default Settings

Year	Landfill Gas	Methane	Carbon Dioxide	NMOC	Landfill Gas	Methane	Waste Placed
	(m^3/year)	*(m^3/year)*	*(m^3/year)*	*(m^3/year)*	*(m^3/hr)*	*(m^3/hr)*	*tonnes*
1995	0	0	0	0	0	0	0
1996	220,019	110,009	110,009	132	25	13	28,000
1997	445,562	222,781	222,781	267	51	25	57,801
1998	588,988	294,494	294,494	353	67	34	78,277
1999	863,209	431,605	431,605	518	99	49	116,114
2000	1,102,523	551,262	551,262	662	126	63	150,877
2001	1,467,898	733,949	733,949	881	168	84	202,877
2002	1,907,764	953,882	953,882	1,145	218	109	266,180
2003	2,482,635	1,241,318	1,241,318	1,490	283	142	348,859
2004	2,948,757	1,474,379	1,474,379	1,769	337	168	420,567
2005	3,270,933	1,635,466	1,635,466	1,963	373	187	476,282
2006	3,390,411	1,695,205	1,695,205	2,034	387	194	507,809
2007	3,596,260	1,798,130	1,798,130	2,158	411	205	550,924
2008	3,488,766	1,744,383	1,744,383	2,093	398	199	555,189
2009	3,351,970	1,675,985	1,675,985	2,011	383	191	555,189
2010	3,220,537	1,610,268	1,610,268	1,932	368	184	555,189
2011	3,094,258	1,547,129	1,547,129	1,857	353	177	555,189
2012	2,972,930	1,486,465	1,486,465	1,784	339	170	555,189
2013	2,856,360	1,428,180	1,428,180	1,714	326	163	555,189
2014	2,744,361	1,372,180	1,372,180	1,647	313	157	555,189
2015	2,636,753	1,318,376	1,318,376	1,582	301	150	555,189
2016	2,533,364	1,266,682	1,266,682	1,520	289	145	555,189
2017	2,434,029	1,217,015	1,217,015	1,460	278	139	555,189
2018	2,338,590	1,169,295	1,169,295	1,403	267	133	555,189
2019	2,246,892	1,123,446	1,123,446	1,348	256	128	555,189
2020	2,158,790	1,079,395	1,079,395	1,295	246	123	555,189
2021	2,074,143	1,037,072	1,037,072	1,244	237	118	555,189
2022	1,992,815	996,407	996,407	1,196	227	114	555,189
2023	1,914,675	957,338	957,338	1,149	219	109	555,189
2024	1,839,600	919,800	919,800	1,104	210	105	555,189
2025	1,767,468	883,734	883,734	1,060	202	101	555,189
2026	1,698,165	849,082	849,082	1,019	194	97	555,189
2027	1,631,579	815,789	815,789	979	186	93	555,189
2028	1,567,604	783,802	783,802	941	179	89	555,189
2029	1,506,137	753,069	753,069	904	172	86	555,189
2030	1,447,081	723,540	723,540	868	165	83	555,189
2031	1,390,340	695,170	695,170	834	159	79	555,189
2032	1,335,824	667,912	667,912	801	152	76	555,189
2033	1,283,445	641,723	641,723	770	147	73	555,189
2034	1,233,121	616,560	616,560	740	141	70	555,189
2035	1,184,769	592,385	592,385	711	135	68	555,189
2036	1,138,314	569,157	569,157	683	130	65	555,189
2037	1,093,680	546,840	546,840	656	125	62	555,189
2038	1,050,796	525,398	525,398	630	120	60	555,189
2039	1,009,594	504,797	504,797	606	115	58	555,189
2040	970,007	485,004	485,004	582	111	55	555,189
2041	931,973	465,986	465,986	559	106	53	555,189
2042	895,429	447,715	447,715	537	102	51	555,189
2043	860,319	430,160	430,160	516	98	49	555,189
2044	826,586	413,293	413,293	496	94	47	555,189
2045	794,175	397,087	397,087	477	91	45	555,189
2046	763,035	381,517	381,517	458	87	44	555,189
2047	733,116	366,558	366,558	440	84	42	555,189
2048	704,370	352,185	352,185	423	80	40	555,189
2049	676,751	338,375	338,375	406	77	39	555,189
2050	650,215	325,108	325,108	390	74	37	555,189
2051	624,720	312,360	312,360	375	71	36	555,189
2052	600,224	300,112	300,112	360	69	34	555,189
2053	576,689	288,345	288,345	346	66	33	555,189
2054	554,077	277,038	277,038	332	63	32	555,189
2055	532,351	266,176	266,176	319	61	30	555,189
2056	511,477	255,739	255,739	307	58	29	555,189
2057	491,422	245,711	245,711	295	56	28	555,189
2058	472,153	236,077	236,077	283	54	27	555,189

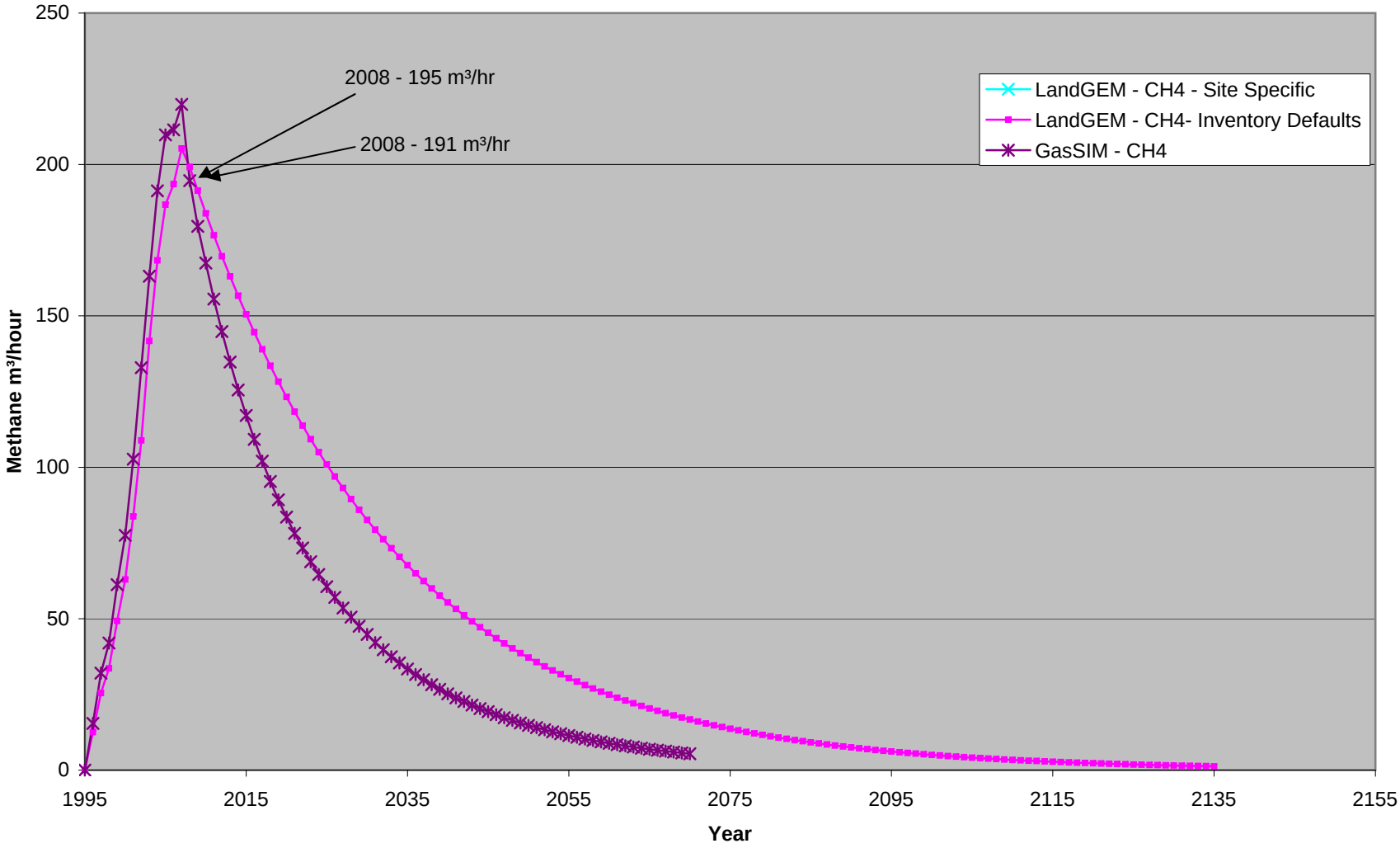
Year	Landfill Gas	Methane	Carbon Dioxide	NMOC	Landfill Gas	Methane	Waste Placed
	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/hr)	(m^3/hr)	tonnes
2059	453,640	226,820	226,820	272	52	26	555,189
2060	435,852	217,926	217,926	262	50	25	555,189
2061	418,762	209,381	209,381	251	48	24	555,189
2062	402,342	201,171	201,171	241	46	23	555,189
2063	386,566	193,283	193,283	232	44	22	555,189
2064	371,409	185,704	185,704	223	42	21	555,189
2065	356,846	178,423	178,423	214	41	20	555,189
2066	342,854	171,427	171,427	206	39	20	555,189
2067	329,410	164,705	164,705	198	38	19	555,189
2068	316,494	158,247	158,247	190	36	18	555,189
2069	304,084	152,042	152,042	182	35	17	555,189
2070	292,161	146,080	146,080	175	33	17	555,189
2071	280,705	140,352	140,352	168	32	16	555,189
2072	269,698	134,849	134,849	162	31	15	555,189
2073	259,123	129,562	129,562	155	30	15	555,189
2074	248,963	124,481	124,481	149	28	14	555,189
2075	239,201	119,600	119,600	144	27	14	555,189
2076	229,822	114,911	114,911	138	26	13	555,189
2077	220,810	110,405	110,405	132	25	13	555,189
2078	212,152	106,076	106,076	127	24	12	555,189
2079	203,833	101,917	101,917	122	23	12	555,189
2080	195,841	97,921	97,921	118	22	11	555,189
2081	188,162	94,081	94,081	113	21	11	555,189
2082	180,784	90,392	90,392	108	21	10	555,189
2083	173,695	86,848	86,848	104	20	10	555,189
2084	166,885	83,442	83,442	100	19	10	555,189
2085	160,341	80,171	80,171	96	18	9	555,189
2086	154,054	77,027	77,027	92	18	9	555,189
2087	148,013	74,007	74,007	89	17	8	555,189
2088	142,210	71,105	71,105	85	16	8	555,189
2089	136,634	68,317	68,317	82	16	8	555,189
2090	131,276	65,638	65,638	79	15	7	555,189
2091	126,129	63,064	63,064	76	14	7	555,189
2092	121,183	60,592	60,592	73	14	7	555,189
2093	116,432	58,216	58,216	70	13	7	555,189
2094	111,866	55,933	55,933	67	13	6	555,189
2095	107,480	53,740	53,740	64	12	6	555,189
2096	103,266	51,633	51,633	62	12	6	555,189
2097	99,216	49,608	49,608	60	11	6	555,189
2098	95,326	47,663	47,663	57	11	5	555,189
2099	91,588	45,794	45,794	55	10	5	555,189
2100	87,997	43,999	43,999	53	10	5	555,189
2101	84,547	42,273	42,273	51	10	5	555,189
2102	81,232	40,616	40,616	49	9	5	555,189
2103	78,046	39,023	39,023	47	9	4	555,189
2104	74,986	37,493	37,493	45	9	4	555,189
2105	72,046	36,023	36,023	43	8	4	555,189
2106	69,221	34,610	34,610	42	8	4	555,189
2107	66,507	33,253	33,253	40	8	4	555,189
2108	63,899	31,949	31,949	38	7	4	555,189
2109	61,393	30,697	30,697	37	7	4	555,189
2110	58,986	29,493	29,493	35	7	3	555,189
2111	56,673	28,337	28,337	34	6	3	555,189
2112	54,451	27,226	27,226	33	6	3	555,189
2113	52,316	26,158	26,158	31	6	3	555,189
2114	50,265	25,132	25,132	30	6	3	555,189
2115	48,294	24,147	24,147	29	6	3	555,189
2116	46,400	23,200	23,200	28	5	3	555,189
2117	44,581	22,290	22,290	27	5	3	555,189
2118	42,833	21,416	21,416	26	5	2	555,189
2119	41,153	20,577	20,577	25	5	2	555,189
2120	39,540	19,770	19,770	24	5	2	555,189
2121	37,989	18,995	18,995	23	4	2	555,189
2122	36,500	18,250	18,250	22	4	2	555,189
2123	35,069	17,534	17,534	21	4	2	555,189
2124	33,693	16,847	16,847	20	4	2	555,189
2125	32,372	16,186	16,186	19	4	2	555,189

Year	Landfill Gas	Methane	Carbon Dioxide	NMOC	Landfill Gas	Methane	Waste Placed
	(m^3/year)	***(m^3/year)***	***(m^3/year)***	***(m^3/year)***	***(m^3/hr)***	***(m^3/hr)***	***tonnes***
2126	31,103	15,551	15,551	19	4	2	555,189
2127	29,883	14,942	14,942	18	3	2	555,189
2128	28,712	14,356	14,356	17	3	2	555,189
2129	27,586	13,793	13,793	17	3	2	555,189
2130	26,504	13,252	13,252	16	3	2	555,189
2131	25,465	12,732	12,732	15	3	1	555,189
2132	24,466	12,233	12,233	15	3	1	555,189
2133	23,507	11,754	11,754	14	3	1	555,189
2134	22,585	11,293	11,293	14	3	1	555,189
2135	21,700	10,850	10,850	13	2	1	555,189

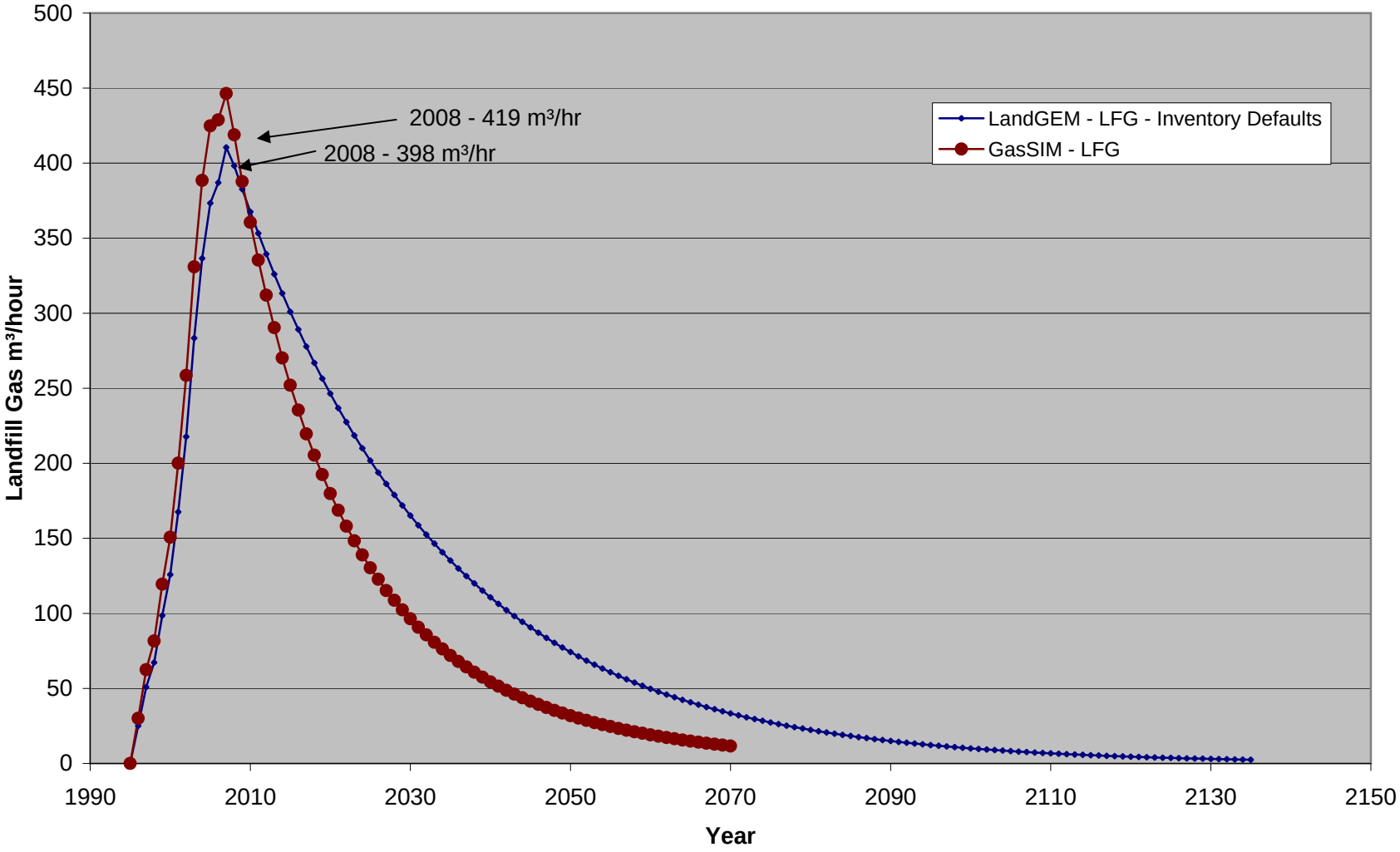
Rossmore Landfill - 2008 Gas Model Outputs
using LandGEM Inventory Default Settings



Rossmore Landfill - 2008 Gas Model Outputs
Comparison of Results - Hourly Production



Rossmore Landfill - 2008 Gas Model Outputs
Comparison of Results - Hourly Production



Appendix D

Meteorological Records for East Cork Landfill

1st January – 31st December 2008

date/time	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Tue Jan 01 23:59:08 2008	0.5	0.2	10.1	11.5	9.2	87.7	96.2	75.4	1014.0	1019.1	1009.1	277	360	1	5	15	1
Wed Jan 02 23:59:08 2008	1.1	0.0	8.3	9.5	7.2	72.3	88.3	66.2	1003.3	1009.3	996.2	299	358	1	8	18	2
Thu Jan 03 23:59:08 2008	1.7	1.4	3.9	7.4	-0.5	79.4	92.5	70.0	996.8	1002.2	993.2	242	360	2	6	18	0
Fri Jan 04 23:59:07 2008	1.1	23.8	3.6	9.3	-3.5	87.8	98.6	74.4	991.4	1002.3	981.6	151	360	1	4	25	0
Sat Jan 05 23:59:07 2008	0.7	0.0	6.1	8.3	2.1	75.5	87.9	58.9	995.2	1004.0	987.9	78	360	1	4	16	0
Sun Jan 06 23:59:07 2008	1.4	5.8	3.8	8.8	-1.0	91.5	98.2	65.2	1001.7	1006.3	993.7	186	360	1	3	17	0
Mon Jan 07 23:59:07 2008	0.8	3.8	6.8	9.4	4.3	74.0	91.2	55.4	1006.8	1010.6	997.6	74	360	1	5	23	0
Tue Jan 08 23:59:07 2008	1.7	10.6	7.6	11.3	3.9	84.1	94.5	60.5	999.1	1009.6	989.8	82	360	1	6	23	0
Wed Jan 09 23:59:07 2008	1.7	21.0	6.1	11.0	1.9	85.9	95.0	75.3	1000.2	1004.7	994.3	68	360	1	5	21	0
Thu Jan 10 23:59:08 2008	1.0	15.2	7.2	11.0	2.1	88.0	93.8	80.7	992.3	995.3	985.8	78	360	1	4	21	0
Fri Jan 11 23:59:07 2008	0.8	1.2	4.0	6.7	2.0	86.5	96.2	67.4	995.7	1001.8	992.2	143	360	1	2	8	0
Sat Jan 12 23:59:08 2008	0.6	12.0	6.3	11.2	1.5	93.4	97.2	85.8	999.1	1003.7	990.4	174	360	1	4	17	0
Sun Jan 13 23:59:08 2008	0.5	8.4	9.5	11.0	7.9	88.1	94.8	79.0	986.2	990.5	983.5	112	360	1	5	16	0
Mon Jan 14 23:59:08 2008	0.9	2.8	8.6	10.2	7.4	83.2	95.4	63.1	986.4	990.4	982.4	71	360	1	5	15	1
Tue Jan 15 23:59:08 2008	1.4	1.2	7.5	9.6	4.6	85.5	95.9	68.3	977.5	984.7	973.8	86	360	1	3	14	0
Wed Jan 16 23:59:07 2008	0.9	1.0	6.4	9.3	4.4	84.5	95.6	72.3	989.6	1000.3	978.1	129	360	1	3	12	0
Thu Jan 17 23:59:07 2008	0.8	2.2	9.4	11.3	6.7	79.8	94.3	64.8	994.5	1004.2	988.7	73	360	1	6	21	1
Fri Jan 18 23:59:07 2008	1.6	1.8	11.9	14.1	6.6	89.7	96.0	73.7	1002.6	1007.8	999.1	81	360	1	6	16	0
Sat Jan 19 23:59:07 2008	1.3	8.6	11.4	12.9	10.0	95.3	97.2	90.5	1012.6	1015.1	1007.7	92	360	1	3	15	0
Sun Jan 20 23:59:07 2008	0.4	4.2	12.3	12.9	11.6	94.9	96.5	92.8	1015.4	1017.3	1013.7	62	360	1	4	12	0
Mon Jan 21 23:59:07 2008	0.4	4.6	10.8	12.6	7.8	84.6	95.1	69.9	1009.6	1016.2	1006.2	71	360	1	6	20	1
Tue Jan 22 23:59:08 2008	1.5	3.4	10.3	12.1	7.3	91.9	95.7	81.6	1018.3	1019.5	1016.1	95	360	1	3	11	0
Wed Jan 23 23:59:08 2008	0.7	0.2	11.7	12.5	9.4	92.2	95.5	78.9	1016.6	1019.3	1014.3	49	360	1	5	16	1
Thu Jan 24 23:59:08 2008	1.0	0.0	7.2	9.6	4.8	75.3	84.1	61.6	1026.1	1032.0	1017.1	68	360	1	4	11	1
Fri Jan 25 23:59:08 2008	1.6	0.0	10.2	12.0	9.0	76.6	81.6	70.0	1031.9	1032.6	1031.2	54	360	1	6	15	1
Sat Jan 26 23:59:08 2008	1.9	0.0	9.6	11.8	7.3	77.8	91.3	61.7	1032.0	1033.2	1030.2	53	360	1	4	12	0
Sun Jan 27 23:59:08 2008	1.6	0.0	7.4	12.6	1.6	92.3	98.7	78.0	1032.1	1033.2	1031.1	113	360	1	1	5	0
Mon Jan 28 23:59:07 2008	0.5	0.0	10.0	11.9	6.4	87.2	93.9	78.0	1028.2	1031.8	1024.0	78	360	1	3	11	0
Tue Jan 29 23:59:07 2008	0.9	5.0	9.1	11.7	4.4	85.5	94.0	73.1	1022.8	1028.0	1019.5	86	360	1	4	14	1
Wed Jan 30 23:59:07 2008	1.1	0.0	5.1	8.4	1.4	82.8	95.0	72.4	1027.6	1031.4	1016.0	78	358	1	4	16	0
Thu Jan 31 23:59:07 2008	0.8	1.6	6.6	10.4	2.4	79.4	94.0	63.9	1002.6	1016.0	999.3	80	360	2	8	21	1
Evap. & Rainfall Totals	**32.9**	**140.0**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Fri Feb 01 23:59:07 2008	1.7	2.0	2.7	4.4	1.0	87.2	95.3	71.5	1004.8	1012.8	999.4	104	206	37	4	13	0
Sat Feb 02 23:59:07 2008	0.7	3.2	5.0	9.7	0.0	86.4	95.7	73.1	1006.8	1013.2	995.2	86	360	1	4	21	0
Sun Feb 03 23:59:08 2008	0.9	3.2	6.3	9.8	0.7	83.2	94.1	72.0	984.9	995.3	980.1	143	360	1	6	24	0
Mon Feb 04 23:59:08 2008	1.1	13.0	5.6	9.9	0.2	84.9	96.3	62.6	989.6	994.5	982.8	110	360	1	4	14	0
Tue Feb 05 23:59:08 2008	1.2	3.4	9.2	11.1	7.3	81.2	88.5	72.6	989.4	1003.9	982.8	64	360	1	6	17	1
Wed Feb 06 23:59:08 2008	1.4	4.4	7.0	10.6	2.3	84.4	95.7	61.9	1019.9	1024.9	1003.9	216	360	1	4	15	0
Thu Feb 07 23:59:08 2008	1.3	0.6	11.5	12.4	10.6	92.0	96.8	82.7	1022.0	1023.4	1020.4	96	360	1	6	14	1
Fri Feb 08 23:59:07 2008	0.9	1.6	10.9	11.3	10.6	91.7	94.1	89.0	1020.3	1021.6	1018.7	162	360	1	6	16	2
Sat Feb 09 23:59:07 2008	0.7	0.0	10.2	10.8	9.5	87.8	91.3	82.0	1023.6	1028.4	1019.7	268	360	1	3	13	0
Sun Feb 10 23:59:07 2008	0.8	0.0	8.9	9.6	7.7	84.8	89.0	80.3	1028.6	1029.6	1027.9	293	360	1	2	7	0
Mon Feb 11 23:59:07 2008	0.7	0.0	8.4	11.9	4.4	89.5	97.6	79.9	1027.2	1028.8	1026.3	287	360	10	3	8	0
Tue Feb 12 23:59:07 2008	0.7	0.4	7.3	11.8	4.3	93.0	98.8	67.8	1030.6	1033.1	1028.5	272	343	153	2	7	0
Wed Feb 13 23:59:07 2008	0.9	0.2	6.5	13.1	2.7	87.6	98.1	63.0	1033.4	1034.3	1032.8	272	360	1	2	6	0
Thu Feb 14 23:59:08 2008	1.0	0.2	4.9	8.3	0.7	87.8	98.5	73.3	1033.7	1034.9	1032.7	230	360	1	2	10	0
Fri Feb 15 23:59:08 2008	0.5	0.0	6.0	6.9	4.9	80.9	87.5	74.7	1035.2	1036.8	1034.0	264	354	16	3	9	0
Sat Feb 16 23:59:08 2008	0.8	0.0	6.4	7.4	5.5	78.0	83.0	71.0	1037.6	1038.6	1036.5	272	334	41	3	8	0
Sun Feb 17 23:59:08 2008	1.0	0.0	3.7	8.2	0.8	87.2	96.2	65.3	1035.6	1038.2	1033.2	266	360	1	2	9	0
Mon Feb 18 23:59:08 2008	0.7	0.0	5.4	8.6	1.6	88.2	96.5	73.7	1028.7	1033.2	1024.9	262	332	79	2	7	0
Tue Feb 19 23:59:08 2008	0.6	0.0	6.7	9.3	3.2	80.3	96.2	63.3	1019.2	1024.9	1015.6	278	360	1	2	8	0
Wed Feb 20 23:59:07 2008	0.9	0.0	6.5	10.9	2.9	88.3	96.4	77.2	1016.5	1019.1	1014.6	122	360	1	1	6	0
Thu Feb 21 23:59:07 2008	0.5	0.0	10.5	12.3	5.4	83.9	88.2	78.1	1018.1	1019.2	1017.2	64	360	1	6	14	1
Fri Feb 22 23:59:07 2008	1.2	0.6	11.2	14.0	7.3	81.4	93.8	60.4	1020.2	1024.0	1016.4	87	360	1	4	14	0
Sat Feb 23 23:59:07 2008	1.8	0.2	10.9	12.9	8.9	87.0	96.4	74.1	1017.4	1023.2	1012.5	53	360	1	6	15	1
Sun Feb 24 23:59:07 2008	1.3	1.2	7.9	10.8	3.6	76.7	93.3	47.0	1015.0	1018.9	1010.7	86	360	1	3	13	0
Mon Feb 25 23:59:07 2008	1.7	6.0	9.1	11.2	2.7	82.3	94.5	61.7	1006.9	1018.6	998.5	100	360	1	6	19	0
Tue Feb 26 23:59:07 2008	1.7	0.0	7.9	10.7	5.5	72.5	86.6	54.2	1006.5	1013.7	998.8	81	360	1	4	18	0
Wed Feb 27 23:59:08 2008	2.0	0.0	6.0	13.7	2.0	84.1	97.7	49.0	1015.8	1018.1	1013.6	148	360	1	1	4	0
Thu Feb 28 23:59:08 2008	0.9	0.0	6.5	10.6	3.4	86.3	96.2	68.2	1018.8	1020.0	1017.0	87	360	1	2	5	0
Fri Feb 29 23:59:08 2008	0.7	1.2	10.5	13.4	5.1	83.8	95.1	56.6	1008.4	1019.5	1001.7	71	360	1	7	23	0
Evap. & Rainfall Totals	**30.3**	**41.4**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Sat Mar 01 23:59:08 2008	2.2	0.0	11.2	13.8	8.0	75.5	90.4	62.5	1010.9	1014.3	1005.0	80	360	1	6	19	1
Sun Mar 02 23:59:07 2008	2.2	0.0	8.3	12.0	3.9	71.7	93.4	52.8	1012.0	1014.5	1009.9	92	360	1	4	16	0
Mon Mar 03 23:59:07 2008	2.0	2.6	3.4	6.0	1.6	83.3	93.1	68.8	1012.6	1021.5	1007.4	101	206	14	5	19	1
Tue Mar 04 23:59:07 2008	1.0	0.0	6.6	10.8	3.0	72.8	90.0	50.6	1032.0	1037.2	1021.5	127	360	1	4	14	0
Wed Mar 05 23:59:07 2008	1.9	0.0	7.7	10.1	4.5	79.9	91.0	66.1	1033.9	1037.1	1029.0	79	357	2	3	9	0
Thu Mar 06 23:59:07 2008	1.1	1.4	9.3	11.0	5.2	78.5	89.7	65.5	1019.4	1029.0	1006.9	58	360	1	5	17	1
Fri Mar 07 23:59:07 2008	1.6	0.0	7.1	10.4	3.9	78.7	90.6	58.9	1008.9	1010.0	1005.6	72	360	1	4	13	1
Sat Mar 08 23:59:07 2008	1.7	0.8	8.9	11.6	4.4	79.8	91.0	52.9	996.4	1005.6	992.4	66	360	1	6	17	1
Sun Mar 09 23:59:07 2008	2.2	15.2	6.1	9.1	3.2	78.6	93.7	42.1	989.2	995.9	960.3	118	360	1	6	27	0
Mon Mar 10 23:59:08 2008	2.2	6.0	6.9	9.1	4.5	79.4	91.3	61.7	966.1	985.3	948.8	88	360	1	8	27	2
Tue Mar 11 23:59:08 2008	1.7	7.6	8.1	12.4	4.9	73.6	96.4	49.6	984.0	990.2	980.1	91	360	1	7	29	0
Wed Mar 12 23:59:08 2008	2.5	0.4	6.6	10.9	2.9	70.3	88.7	44.7	1003.4	1010.6	990.0	83	160	4	6	22	1
Thu Mar 13 23:59:08 2008	2.6	1.0	8.1	12.3	4.3	86.0	95.0	72.8	1007.7	1010.6	1005.4	100	360	1	2	10	0
Fri Mar 14 23:59:07 2008	0.8	6.2	8.0	11.3	4.7	91.6	94.5	87.1	1006.7	1008.8	1002.7	267	360	1	3	10	0
Sat Mar 15 23:59:07 2008	0.5	13.4	9.7	10.5	8.7	94.6	96.2	91.5	997.2	1002.7	994.8	276	360	1	3	11	0
Sun Mar 16 23:59:07 2008	0.4	0.0	8.1	10.9	3.3	85.0	95.6	70.3	1007.7	1015.3	998.4	217	333	56	2	7	0
Mon Mar 17 23:59:07 2008	0.8	0.0	5.9	10.0	2.7	77.9	92.7	56.4	1016.6	1019.1	1014.8	264	340	166	4	14	0
Tue Mar 18 23:59:07 2008	1.6	0.0	5.4	11.4	1.8	71.9	90.5	43.4	1022.6	1025.7	1019.0	234	360	1	2	7	0
Wed Mar 19 23:59:07 2008	1.6	0.0	6.5	11.4	2.3	71.9	89.1	41.2	1027.3	1028.5	1025.4	125	277	10	2	8	0
Thu Mar 20 23:59:07 2008	1.9	0.0	8.7	11.9	4.6	82.7	90.2	71.8	1018.1	1028.0	1005.7	90	360	3	5	19	1
Fri Mar 21 23:59:08 2008	1.4	0.0	8.3	11.7	3.6	71.1	88.4	52.3	1002.6	1006.3	999.9	139	360	1	8	25	0
Sat Mar 22 23:59:08 2008	2.5	0.0	5.3	9.3	2.2	64.0	83.2	42.1	1011.8	1014.4	1006.3	156	254	57	5	14	0
Sun Mar 23 23:59:08 2008	2.3	0.4	7.2	11.1	3.5	74.6	87.3	44.0	1006.8	1013.2	1004.7	124	230	40	5	18	0
Mon Mar 24 23:59:08 2008	2.4	1.2	9.1	12.9	5.7	85.2	96.1	70.4	1005.1	1009.8	1002.2	121	359	3	4	15	0
Tue Mar 25 23:59:08 2008	1.3	3.4	8.0	12.0	4.4	82.0	91.9	67.0	1007.5	1010.5	1002.4	106	360	1	2	9	0
Wed Mar 26 23:59:07 2008	1.1	0.0	6.2	9.8	1.9	78.1	91.0	59.6	1000.5	1002.4	999.1	102	176	28	4	13	0
Thu Mar 27 23:59:07 2008	1.5	5.4	5.7	11.0	0.2	84.1	96.7	49.3	998.6	1001.8	989.0	184	360	1	3	15	0
Fri Mar 28 23:59:07 2008	1.8	4.6	8.4	11.7	4.9	76.9	96.3	51.1	993.1	1002.2	984.7	79	360	1	7	23	1
Sat Mar 29 23:59:07 2008	2.3	6.8	8.4	11.5	4.1	80.0	91.5	69.5	992.4	1002.3	986.2	104	360	1	6	22	0
Sun Mar 30 23:59:07 2008	1.5	3.8	7.0	9.9	3.6	84.8	94.4	69.3	993.3	1000.6	991.0	210	360	1	4	16	0
Mon Mar 31 23:59:07 2008	1.1	2.4	8.1	12.1	3.5	86.8	96.5	64.4	1009.7	1013.1	1000.6	131	360	1	4	13	0
Evap. & Rainfall Totals	**51.8**	**82.6**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Tue Apr 01 23:59:07 2008	1.4	0.0	11.5	14.6	8.6	67.7	89.5	43.9	1017.0	1023.3	1009.0	77	360	1	6	15	1
Wed Apr 02 23:59:08 2008	3.2	0.0	13.0	17.9	9.2	80.0	94.3	56.3	1026.2	1030.1	1023.1	98	354	5	2	8	0
Thu Apr 03 23:59:08 2008	2.1	0.0	10.7	15.9	7.7	89.6	96.8	68.6	1030.5	1031.8	1029.3	182	360	1	2	9	0
Fri Apr 04 23:59:08 2008	1.2	0.0	10.7	15.2	8.0	81.6	97.1	51.4	1027.0	1029.8	1023.3	144	360	1	2	8	0
Sat Apr 05 23:59:08 2008	1.6	0.0	8.1	11.8	4.0	67.1	92.2	41.1	1021.3	1023.3	1019.1	156	261	50	4	12	0
Sun Apr 06 23:59:08 2008	2.4	0.0	4.8	10.0	1.0	66.2	89.2	36.2	1013.8	1019.8	1009.0	146	360	60	5	18	1
Mon Apr 07 23:59:08 2008	2.6	0.4	4.2	10.6	0.6	76.7	90.8	41.7	1005.9	1009.0	1003.5	132	360	1	3	14	0
Tue Apr 08 23:59:07 2008	2.0	0.0	5.2	9.7	0.4	80.1	94.6	60.8	1002.2	1003.5	1001.5	109	360	1	1	6	0
Wed Apr 09 23:59:07 2008	0.8	0.0	6.7	11.3	3.5	77.8	91.4	52.7	998.8	1001.4	997.4	96	360	1	2	8	0
Thu Apr 10 23:59:07 2008	1.3	1.0	6.4	10.7	3.2	77.7	93.7	46.6	994.4	997.9	990.0	88	354	1	3	14	0
Fri Apr 11 23:59:07 2008	1.9	1.8	6.7	10.2	4.6	76.5	89.8	55.2	993.7	997.4	989.8	88	179	6	5	15	1
Sat Apr 12 23:59:07 2008	2.0	0.0	7.6	14.1	2.0	74.8	95.4	43.4	1000.8	1003.9	997.3	96	360	1	3	13	0
Sun Apr 13 23:59:07 2008	2.3	0.4	7.9	13.3	4.1	75.8	91.4	47.1	1010.0	1017.2	1003.8	131	270	44	3	13	0
Mon Apr 14 23:59:07 2008	2.3	0.0	8.4	14.3	3.6	71.2	94.3	35.3	1020.8	1023.0	1017.2	122	360	1	2	9	0
Tue Apr 15 23:59:08 2008	2.3	0.0	7.7	13.5	2.7	77.8	93.8	47.9	1021.1	1023.0	1019.4	175	360	1	2	9	0
Wed Apr 16 23:59:08 2008	1.7	0.0	8.6	11.0	4.6	73.7	93.7	54.6	1012.7	1019.4	1006.7	292	360	227	7	19	0
Thu Apr 17 23:59:08 2008	2.2	0.0	8.2	10.9	6.2	69.6	82.5	51.6	1002.8	1006.6	999.7	267	349	146	6	19	1
Fri Apr 18 23:59:08 2008	2.6	1.4	7.3	12.7	4.3	71.5	85.1	48.2	996.2	999.7	994.4	243	338	6	5	14	1
Sat Apr 19 23:59:08 2008	2.5	0.4	7.7	9.4	6.5	79.0	90.5	70.8	996.8	999.1	995.1	241	342	52	4	13	1
Sun Apr 20 23:59:07 2008	1.2	0.6	8.6	11.3	6.8	86.8	92.9	78.1	1002.0	1005.4	998.9	227	333	11	3	9	0
Mon Apr 21 23:59:07 2008	0.8	0.0	9.9	14.1	8.2	80.7	89.6	65.9	1006.8	1008.4	1005.2	194	360	1	2	7	0
Tue Apr 22 23:59:07 2008	1.2	8.2	8.8	12.9	4.2	90.3	96.6	73.8	1005.7	1008.4	1003.3	252	360	1	3	11	0
Wed Apr 23 23:59:07 2008	1.0	5.6	10.5	14.1	7.0	90.2	97.2	77.8	1010.5	1012.7	1007.1	171	360	1	4	15	0
Thu Apr 24 23:59:07 2008	1.2	1.4	10.8	14.7	7.5	79.2	93.5	55.6	1014.1	1020.7	1007.6	57	360	1	4	14	0
Fri Apr 25 23:59:07 2008	2.3	2.0	11.5	12.9	10.1	93.4	96.5	87.5	1018.6	1020.7	1017.0	100	360	1	5	14	1
SatApr 26 23:59:07 2009	2.4	1.2	12.1	14.6	8.4	82.0	94.0	56.0	1009.6	1019.6	1017.2	243	360	141	4	12	0
Sun Apr 27 23:59:08 2008	2.5	1.4	8.8	13.3	5.2	80.2	94.9	57.9	996.4	1001.4	990.3	178	360	1	3	11	0
Mon Apr 28 23:59:08 2008	1.6	0.8	8.9	12.8	6.2	78.6	90.2	61.7	991.4	993.4	989.9	161	319	64	5	14	1
Tue Apr 29 23:59:08 2008	1.9	0.0	8.6	13.6	4.0	75.8	92.2	51.7	996.8	1001.3	993.3	115	359	2	3	12	0
Wed Apr 30 23:59:07 2008	2.1	1.4	9.9	13.3	5.7	79.3	95.9	53.0	1006.9	1012.8	1001.3	192	360	1	3	10	0
Evap. & Rainfall Totals	**56.4**	**28.0**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Fri May 02 23:59:08 2008	0.0	0.0	12.1	14.2	11.3	89.0	94.5	80.0	1014.0	1014.2	1013.4	327	43	267	5	11	2
Sat May 03 23:59:08 2008	1.7	1.6	12.2	14.7	10.8	87.6	94.1	79.4	1010.8	1013.6	1007.7	313	360	1	6	14	2
Sun May 04 23:59:08 2008	1.4	19.4	13.4	16.4	11.4	83.9	96.9	61.8	1014.3	1021.3	1007.5	135	360	1	4	14	0
Mon May 05 23:59:08 2008	2.2	0.0	11.4	14.1	8.5	90.6	97.7	77.3	1022.7	1023.8	1021.3	305	360	1	3	6	0
Tue May 06 23:59:07 2008	1.0	0.0	12.9	17.9	8.2	84.7	96.8	63.6	1018.6	1021.8	1017.0	272	357	3	3	9	0
Wed May 07 23:59:07 2008	2.2	0.0	12.2	16.7	9.0	88.4	96.3	71.4	1014.8	1017.3	1012.2	274	350	189	3	8	0
Thu May 08 23:59:07 2008	1.5	9.2	12.9	15.7	9.4	88.7	97.1	75.7	1007.4	1012.2	1005.7	262	360	1	3	14	0
Fri May 09 23:59:07 2008	1.2	0.0	13.8	16.5	11.7	80.8	96.7	64.2	1010.6	1014.3	1007.2	123	242	31	2	7	0
Sat May 10 23:59:07 2008	1.6	2.8	13.8	18.2	11.7	87.0	95.5	72.6	1016.3	1018.8	1014.3	159	360	1	1	6	0
Sun May 11 23:59:07 2008	0.9	0.2	14.3	18.7	12.1	90.9	97.3	76.7	1018.6	1019.4	1017.7	227	360	1	1	6	0
Mon May 12 23:59:07 2008	1.2	0.0	15.4	21.5	10.6	82.2	97.8	61.3	1016.7	1018.0	1016.0	193	360	1	2	8	0
Tue May 13 23:59:07 2008	2.3	0.0	16.2	21.5	11.2	69.4	93.6	46.7	1015.8	1016.6	1014.8	270	354	133	3	11	0
Wed May 14 23:59:08 2008	3.5	0.0	15.4	20.6	11.1	72.5	88.9	57.6	1013.5	1015.8	1011.3	255	360	1	2	8	0
Thu May 15 23:59:08 2008	2.6	0.0	12.7	17.8	8.7	76.2	87.9	58.9	1009.9	1011.6	1009.0	249	360	6	2	8	0
Fri May 16 23:59:08 2008	2.1	0.0	12.5	16.9	10.1	82.5	92.3	63.9	1007.8	1009.7	1006.8	240	360	1	1	4	0
Sat May 17 23:59:08 2008	0.7	5.8	12.1	15.5	9.8	88.6	96.6	71.5	1007.5	1010.1	1006.2	261	360	1	1	7	0
Sun May 18 23:59:07 2008	1.0	0.4	11.2	13.4	7.9	88.1	94.9	73.0	1012.9	1015.9	1010.1	267	360	1	2	9	0
Mon May 19 23:59:07 2008	1.0	0.0	11.4	15.9	7.2	80.6	93.4	67.4	1015.1	1015.9	1014.7	275	360	1	3	12	0
Tue May 20 23:59:07 2008	1.6	0.0	11.8	13.5	7.6	73.6	88.8	56.0	1013.2	1015.0	1011.3	305	360	1	5	14	0
Wed May 21 23:59:07 2008	2.4	37.4	12.3	13.3	11.2	86.7	96.1	73.6	1008.2	1011.4	1006.1	306	360	1	7	16	0
Thu May 22 23:59:07 2008	1.5	0.0	13.7	17.6	11.7	86.6	96.0	62.9	1006.8	1008.3	1005.3	275	360	1	2	8	0
Fri May 23 23:59:07 2008	1.7	6.2	13.6	16.3	11.3	89.3	96.6	77.7	1008.2	1009.1	1006.8	284	360	5	3	9	0
Sat May 24 23:59:07 2008	1.3	0.0	15.1	20.2	10.6	70.4	94.0	46.7	1010.7	1014.5	1008.5	229	358	12	3	11	0
Sun May 25 23:59:08 2008	3.2	2.6	12.6	18.9	8.8	75.2	90.5	52.4	1012.9	1014.4	1011.6	207	359	12	5	14	0
Mon May 26 23:59:08 2008	3.3	0.4	12.7	18.7	9.2	66.3	84.8	37.3	1012.7	1014.4	1010.9	219	354	7	4	15	0
Tue May 27 23:59:08 2008	4.2	0.4	11.4	12.5	9.6	82.0	94.6	65.0	1009.9	1011.2	1007.6	224	354	1	3	11	0
Wed May 28 23:59:08 2008	1.3	0.0	13.2	17.6	9.9	84.8	95.4	66.5	1005.1	1007.6	1003.9	117	360	1	1	6	0
Thu May 29 23:59:08 2008	1.1	0.0	12.7	18.1	8.7	88.0	96.1	72.7	1009.5	1011.9	1007.2	249	360	1	2	9	0
Fri May 30 23:59:07 2008	1.3	0.0	14.3	18.6	11.0	87.3	96.6	72.6	1013.0	1015.1	1011.4	265	360	1	1	5	0
Sat May 31 23:59:07 2008	1.1	0.0	14.8	19.9	11.4	86.3	97.7	61.3	1015.9	1016.7	1014.9	242	360	1	1	6	0
Evap. & Rainfall Totals	**52.0**	**86.4**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Sun Jun 01 23:59:07 2008	1.6	0.0	15.6	22.6	9.8	81.0	97.4	46.1	1014.4	1016.6	1012.5	226	360	1	1	6	0
Mon Jun 02 23:59:07 2008	2.2	0.0	14.9	19.4	10.8	82.0	97.1	60.1	1011.3	1012.9	1009.7	200	360	1	2	9	0
Tue Jun 03 23:59:07 2008	2.1	0.0	13.8	20.1	8.9	68.6	90.3	37.1	1014.0	1015.4	1011.4	77	360	1	2	11	0
Wed Jun 04 23:59:07 2008	3.4	6.0	13.1	17.6	9.0	77.4	95.1	47.5	1011.2	1014.3	1008.9	158	360	1	4	15	0
Thu Jun 05 23:59:08 2008	2.7	0.0	12.5	19.4	7.2	70.2	90.6	40.0	1015.5	1017.8	1014.3	114	360	1	2	9	0
Fri Jun 06 23:59:08 2008	2.9	0.0	12.9	19.1	6.9	72.0	93.2	42.7	1018.8	1020.3	1017.8	106	360	1	1	8	0
Sat Jun 07 23:59:08 2008	2.1	0.0	13.5	18.7	7.4	74.3	94.8	44.3	1020.5	1021.9	1019.8	139	360	1	1	7	0
Sun Jun 08 23:59:08 2008	2.3	0.0	15.7	19.6	11.6	87.7	93.6	73.5	1024.1	1026.1	1021.9	117	360	1	2	7	0
Mon Jun 09 23:59:08 2008	1.3	0.0	18.4	25.0	13.6	77.5	95.4	16.9	1026.1	1026.9	1025.0	124	360	1	2	11	0
Tue Jun 10 23:59:08 2008	4.9	0.0	17.1	22.5	13.5	68.4	86.8	48.9	1026.8	1027.8	1025.8	140	277	11	3	10	0
Wed Jun 11 23:59:07 2008	3.9	0.0	17.1	22.0	12.9	78.9	90.2	60.7	1024.3	1026.8	1021.3	117	212	10	3	13	0
Thu Jun 12 23:59:07 2008	2.8	0.0	13.6	17.9	9.3	72.2	90.8	48.9	1022.0	1023.1	1021.0	148	340	2	3	10	0
Fri Jun 13 23:59:07 2008	2.6	0.0	12.2	16.6	8.6	74.6	86.8	55.6	1019.6	1021.3	1017.6	131	233	9	2	8	0
Sat Jun 14 23:59:07 2008	2.4	0.0	13.9	19.0	10.0	68.3	88.7	46.7	1015.8	1018.4	1013.7	123	360	1	1	6	0
Sun Jun 15 23:59:07 2008	2.0	0.0	12.9	18.5	8.8	70.5	89.3	42.5	1012.0	1013.7	1011.0	160	360	1	0	6	0
Mon Jun 16 23:59:08 2008	0.7	0.0	13.2	19.1	8.1	63.1	83.3	39.0	1012.3	1013.5	1011.2	137	360	1	1	8	0
Tue Jun 17 23:59:08 2008	1.3	1.6	14.0	18.6	10.7	76.7	92.6	53.3	1007.1	1011.2	1004.3	52	360	1	4	15	0
Wed Jun 18 23:59:08 2008	2.9	24.4	13.3	16.0	11.1	90.3	96.5	81.8	1001.3	1004.7	995.9	75	360	1	2	14	0
Thu Jun 19 23:59:08 2008	0.8	0.0	14.0	20.0	9.0	72.6	91.7		1007.8	1013.7	1001.9	95	219	3	2	10	0
Fri Jun 20 23:59:08 2008	4.3	0.0	13.8	17.8	9.6	78.5	93.7	53.6	1014.9	1015.8	1013.7	202	360	1	1	7	0
Sat Jun 21 23:59:07 2008	1.5	34.6	14.0	15.9	11.3	95.4	97.3	88.4	1005.7	1014.7	997.4	215	360	1	3	13	0
Sun Jun 22 23:59:07 2008	0.5	0.6	14.3	17.7	11.4	72.1	94.5	53.1	1006.3	1015.8	995.3	99	360	1	1	15	0
Mon Jun 23 23:59:07 2008	1.8	0.0	13.7	17.3	9.3	84.1	95.1	66.8	1017.2	1018.1	1015.8	206	360	1	1	11	0
Tue Jun 24 23:59:07 2008	1.6	5.2	13.8	14.8	12.5	91.2	95.1	81.8	1010.6	1016.4	1004.1	299	360	1	5	16	1
Wed Jun 25 23:59:07 2008	1.1	1.0	15.5	19.1	12.6	74.2	94.7	47.8	1009.6	1015.7	1003.3	69	360	1	6	15	1
Thu Jun 26 23:59:07 2008	3.9	12.0	14.7	16.6	12.6	86.7	93.4	70.9	1012.7	1015.6	1008.9	58	360	1	5	16	0
Fri Jun 27 23:59:07 2008	1.8	2.4	16.4	20.7	13.2	88.7	95.3	76.7	1013.0	1014.6	1011.3	58	360	1	4	12	0
Sat Jun 28 23:59:08 2008	1.8	0.0	16.0	19.5	12.8	81.5	93.9	63.5	1014.5	1014.9	1014.0	60	360	1	4	11	1
Sun Jun 29 23:59:08 2008	2.5	3.6	15.4	18.9	13.0	76.0	95.2	52.6	1014.6	1017.3	1012.8	74	360	1	4	11	0
Mon Jun 30 23:59:08 2008	3.1	0.0	14.5	17.4	11.6	88.1	92.1	78.9	1014.7	1017.3	1008.8	177	360	1	4	15	0
Evap. & Rainfall Totals	**68.8**	**91.4**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Tue Jul 01 23:59:08 2008	1.5	15.4	15.1	17.1	14.0	87.5	96.0	72.2	1002.6	1008.8	999.5	223	360	1	6	16	1
Wed Jul 02 23:59:07 2008	2.0	15.8	14.4	17.4	11.8	86.6	93.1	68.8	1000.8	1003.8	998.9	144	360	1	3	12	0
Thu Jul 03 23:59:07 2008	1.7	4.2	13.6	18.1	10.8	82.0	93.9	58.2	1006.7	1010.7	1003.8	103	360	1	3	10	0
Fri Jul 04 23:59:07 2008	2.2	34.0	12.4	15.2	7.5	92.4	96.8	82.1	1006.1	1010.8	997.8	267	360	1	5	19	0
Sat Jul 05 23:59:07 2008	1.0	16.0	15.1	20.4	13.3	86.3	96.7	21.5	996.3	998.4	993.8	207	360	1	3	12	0
Sun Jul 06 23:59:07 2008	4.5	3.6	14.7	18.4	12.0	85.2	92.6	70.4	996.9	998.4	995.8	112	193	26	3	12	0
Mon Jul 07 23:59:07 2008	1.9	0.0	14.8	17.8	12.7	77.6	89.4	55.5	999.7	1004.5	997.2	114	196	17	4	13	1
Tue Jul 08 23:59:08 2008	2.9	4.0	14.3	19.1	11.2	76.1	95.7	51.9	1006.7	1008.1	1004.4	109	360	1	3	9	1
Wed Jul 09 23:59:08 2008	2.9	5.0	15.2	17.6	13.1	91.1	96.8	78.9	1001.5	1006.1	999.0	198	360	1	3	12	0
Thu Jul 10 23:59:08 2008	1.3	1.4	15.4	19.9	12.1	82.4	92.0	62.3	1000.7	1002.5	999.2	79	360	1	3	11	0
Fri Jul 11 23:59:08 2008	2.6	0.0	14.4	17.5	11.8	76.2	91.8	53.3	1006.5	1011.4	1002.5	137	240	31	4	11	0
Sat Jul 12 23:59:08 2008	2.8	1.2	13.7	18.4	11.0	78.7	92.2	57.7	1011.3	1011.9	1010.3	112	199	15	3	10	0
Sun Jul 13 23:59:08 2008	2.2	0.0	13.9	17.3	8.7	87.0	95.4	69.1	1013.3	1015.7	1011.6	123	360	1	2	8	0
Mon Jul 14 23:59:07 2008	1.4	0.0	18.6	22.3	15.0	83.7	95.2	68.7	1019.8	1023.9	1015.7	94	360	1	2	7	0
Tue Jul 15 23:59:07 2008	1.9	0.0	17.5	21.4	13.4	79.9	93.8	66.3	1024.9	1026.8	1023.2	100	360	1	3	8	0
Wed Jul 16 23:59:07 2008	2.3	0.0	15.2	18.4	12.2	71.9	87.5	53.5	1023.8	1026.6	1019.9	104	186	7	3	9	0
Thu Jul 17 23:59:07 2008	2.6	0.0	16.1	21.2	12.7	73.6	87.1	46.7	1014.8	1019.9	1012.0	96	187	6	3	11	0
Fri Jul 18 23:59:07 2008	3.6	0.0	17.6	22.4	15.1	80.0	92.2	62.1	1008.9	1012.1	1007.1	84	360	1	3	9	0
Sat Jul 19 23:59:07 2008	2.9	0.0	16.0	20.0	12.6	71.3	87.3	48.2	1011.4	1017.8	1007.2	123	221	29	5	14	1
Sun Jul 20 23:59:07 2008	4.0	0.0	14.6	19.9	10.0	72.0	92.5	48.1	1021.9	1025.6	1017.8	130	204	26	4	11	0
Mon Jul 21 23:59:08 2008	3.3	0.0	15.2	21.0	9.2	78.8	93.1	57.7	1026.0	1026.7	1025.2	120	360	1	2	7	0
Tue Jul 22 23:59:08 2008	2.2	0.0	16.9	21.7	13.5	80.8	93.3	66.1	1024.7	1026.5	1023.1	97	360	1	2	8	0
Wed Jul 23 23:59:08 2008	2.1	0.0	15.7	20.3	13.1	86.2	95.4	68.8	1019.9	1023.1	1015.9	226	360	1	3	8	0
Thu Jul 24 23:59:08 2008	1.9	0.0	17.3	21.1	13.5	85.0	95.5	70.0	1010.3	1016.1	1006.8	276	360	4	4	12	0
Fri Jul 25 23:59:08 2008	2.2	0.6	17.8	22.7	14.6	81.8	95.7	62.6	1006.6	1011.9	1004.4	203	360	1	3	9	0
Sat Jul 26 23:59:07 2008	2.4	0.0	15.8	20.4	10.5	84.1	95.3	66.7	1014.2	1015.7	1011.9	190	360	1	2	9	0
Sun Jul 27 23:59:07 2008	2.0	0.0	17.2	20.9	14.2	84.6	95.2	64.7	1015.6	1016.3	1014.7	273	360	1	2	7	0
Mon Jul 28 23:59:07 2008	2.2	9.2	15.6	18.9	12.9	93.2	95.9	89.0	1011.1	1015.4	1007.5	245	360	1	1	7	0
Tue Jul 29 23:59:07 2008	0.4	32.0	15.5	17.0	14.1	93.8	96.2	89.4	1004.5	1007.5	1003.1	194	360	1	3	11	0
Wed Jul 30 23:59:07 2008	0.6	7.8	17.0	20.2	14.1	82.2	96.2	56.2	1005.8	1008.7	1002.4	177	360	1	4	11	0
Thu Jul 31 23:59:07 2008	2.9	16.0	14.9	18.9	13.2	93.6	95.9	81.9	1002.7	1006.6	998.7	204	360	1	1	5	0
Evap. & Rainfall Totals	**70.1**	**166.2**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Fri Aug 01 23:59:07 2008	0.6	2.2	16.5	21.6	13.7	80.9	94.2	55.9	1004.5	1007.4	1000.2	65	360	1	4	11	0
Sat Aug 02 23:59:08 2008	3.3	0.2	16.8	21.5	13.4	81.8	93.6	61.3	1008.2	1009.1	1006.9	74	360	1	3	11	0
Sun Aug 03 23:59:08 2008	2.6	2.8	16.5	20.5	13.9	77.3	91.5	53.1	1007.3	1008.8	1005.6	78	360	1	3	12	0
Mon Aug 04 23:59:08 2008	3.1	3.2	15.9	19.4	13.9	83.8	94.7	63.0	1008.8	1010.3	1007.0	136	360	1	2	7	0
Tue Aug 05 23:59:08 2008	1.8	9.6	17.1	20.1	14.3	91.2	96.7	79.1	1004.6	1007.7	1003.1	136	360	1	3	10	0
Wed Aug 06 23:59:08 2008	1.5	1.2	17.5	21.6	14.7	88.1	96.7	67.3	1003.3	1006.1	1002.4	244	360	1	3	11	0
Thu Aug 07 23:59:07 2008	2.5	0.2	16.4	20.0	13.0	84.5	96.6	66.3	1005.2	1010.9	1002.2	160	357	1	3	12	0
Fri Aug 08 23:59:07 2008	2.1	0.0	15.1	20.2	10.1	77.3	92.8	51.6	1013.1	1014.6	1010.9	114	360	1	3	9	0
Sat Aug 09 23:59:07 2008	2.7	10.2	17.3	20.5	14.0	90.8	96.5	76.7	1002.3	1010.8	998.0	86	360	1	5	11	1
Sun Aug 10 23:59:07 2008	1.7	0.4	15.9	19.7	13.7	81.2	90.2	67.3	998.9	1001.4	996.5	69	360	1	5	13	1
Mon Aug 11 23:59:07 2008	2.6	11.6	14.5	18.0	11.8	88.9	95.1	76.2	994.4	1001.3	986.1	105	360	1	3	12	0
Tue Aug 12 23:59:08 2008	1.3	0.8	13.2	17.0	10.7	84.1	95.5	59.8	987.4	991.4	983.9	89	359	7	3	13	0
Wed Aug 13 23:59:08 2008	1.9	4.8	13.8	17.0	10.8	82.5	93.5	58.6	998.0	1006.3	989.0	93	360	2	5	15	0
Thu Aug 14 23:59:08 2008	2.5	2.4	12.8	18.4	8.1	85.3	96.6	60.1	1009.1	1013.0	1006.3	154	360	1	2	7	0
Fri Aug 15 23:59:08 2008	1.6	9.8	13.1	16.8	8.6	90.0	96.4	76.8	1009.3	1013.3	1000.2	218	360	1	3	13	0
Sat Aug 16 23:59:08 2008	1.1	17.4	15.6	18.1	13.3	83.6	97.0	60.1	996.8	1000.2	994.6	139	360	1	4	13	1
Sun Aug 17 23:59:08 2008	2.4	10.6	14.0	16.8	11.3	89.1	96.3	75.7	997.4	999.9	993.3	154	360	1	4	14	0
Mon Aug 18 23:59:08 2008	1.3	15.4	15.2	17.4	13.9	91.5	95.8	84.4	989.0	995.7	984.6	192	360	1	5	14	1
Tue Aug 19 23:59:07 2008	1.1	0.0	16.2	20.0	14.0	80.2	93.7	65.9	1002.1	1007.0	995.7	101	191	9	4	12	1
Wed Aug 20 23:59:07 2008	2.5	0.6	15.5	19.5	12.6	87.7	96.2	75.2	1006.5	1008.6	1005.5	96	360	1	3	9	0
Thu Aug 21 23:59:07 2008	1.4	0.0	15.7	21.3	12.4	81.3	94.3	61.0	1012.3	1016.5	1008.6	107	226	5	2	9	0
Fri Aug 22 23:59:07 2008	2.1	0.0	14.4	18.4	10.8	79.3	92.1	59.9	1017.5	1018.4	1016.4	114	360	1	2	9	0
Sat Aug 23 23:59:07 2008	1.9	5.0	14.2	16.2	11.7	92.0	95.8	83.4	1009.3	1017.6	1002.0	127	360	1	3	13	0
Sun Aug 24 23:59:07 2008	0.8	1.0	15.2	18.5	12.0	86.9	94.0	73.3	1005.2	1006.2	1002.7	58	360	1	3	10	0
Mon Aug 25 23:59:08 2008	1.7	0.0	16.6	17.7	15.4	87.4	95.0	79.4	1008.0	1013.1	1004.6	58	360	1	4	11	1
Tue Aug 26 23:59:08 2008	1.4	0.0	16.8	19.5	15.5	88.2	95.0	76.7	1015.8	1018.7	1012.9	53	360	1	4	11	1
Wed Aug 27 23:59:08 2008	1.7	0.0	16.9	18.8	15.5	86.0	91.6	79.0	1019.4	1021.1	1017.9	73	360	1	3	8	0
Thu Aug 28 23:59:08 2008	1.3	0.0	18.1	24.5	13.6	82.8	93.2		1020.0	1021.1	1018.7	109	360	1	2	7	0
Fri Aug 29 23:59:08 2008	5.3	0.0	16.8	19.8	14.9	91.3	96.6	80.2	1017.1	1019.5	1014.5	237	360	1	1	5	0
Sat Aug 30 23:59:08 2008	0.9	2.8	16.0	18.6	14.8	89.5	97.1		1011.5	1014.5	1009.6	218	360	1	3	8	0
Sun Aug 31 23:59:07 2008	4.8	3.0	14.7	18.9	12.3	81.7	94.6	56.7	1009.9	1011.2	1007.1	94	360	1	3	10	0
Evap. & Rainfall Totals	**63.5**	**115.2**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Mon Sep 01 23:59:07 2008	2.4	0.8	14.3	17.8	11.2	78.0	94.8		1004.8	1007.0	1001.6	57	360	1	3	11	0
Tue Sep 02 23:59:07 2008	4.9	2.8	13.4	16.5	10.6	80.5	90.5	64.5	998.3	1001.8	995.3	71	360	1	5	16	1
Wed Sep 03 23:59:07 2008	2.2	10.8	12.5	15.7	9.1	84.7	96.0		996.3	1001.2	993.6	70	360	1	4	16	0
Thu Sep 04 23:59:08 2008	4.5	4.8	13.2	18.4	11.0	86.7	94.5	64.6	993.7	995.7	990.6	145	360	1	2	8	0
Fri Sep 05 23:59:08 2008	1.5	23.6	12.8	13.6	11.9	87.7	95.4	4.0	984.6	990.6	982.0	189	360	15	4	13	1
Sat Sep 06 23:59:08 2008	4.1	0.6	13.9	17.6	11.3	81.3	91.4	61.4	998.5	1007.3	988.5	145	270	24	4	15	0
Sun Sep 07 23:59:08 2008	2.3	0.0	12.5	16.1	8.4	75.3	90.9	52.2	1009.1	1010.8	1007.0	113	360	2	2	8	0
Mon Sep 08 23:59:08 2008	1.9	2.4	13.3	16.6	9.4	88.5	94.6	78.7	1008.1	1010.6	1004.6	261	360	1	3	11	0
Tue Sep 09 23:59:08 2008	1.0	49.4	14.0	16.5	10.7	87.8	97.3	71.8	998.8	1005.3	992.6	151	360	1	6	18	0
Wed Sep 10 23:59:08 2008	1.8	10.8	13.7	16.3	8.7	90.6	97.0	81.1	998.3	1005.6	991.4	195	360	1	5	16	0
Thu Sep 11 23:59:08 2008	1.0	1.4	14.1	16.4	10.7	83.3	93.3	64.4	997.8	1007.7	990.4	81	360	1	5	16	0
Fri Sep 12 23:59:07 2008	2.1	0.0	13.3	17.6	9.5	83.5	94.3	67.0	1013.1	1016.7	1007.7	108	358	2	2	8	0
Sat Sep 13 23:59:07 2008	1.4	2.8	12.0	15.4	6.5	94.1	97.1	87.1	1017.2	1019.1	1015.8	249	360	1	2	8	0
Sun Sep 14 23:59:07 2008	0.5	15.4	14.7	15.9	13.4	95.3	96.3	92.0	1018.5	1019.7	1017.7	249	360	1	3	11	0
Mon Sep 15 23:59:07 2008	0.4	0.0	14.2	18.6	12.1	85.5	95.1	66.7	1021.4	1023.1	1019.6	130	245	21	2	8	0
Tue Sep 16 23:59:07 2008	1.6	0.0	13.1	16.1	10.2	84.4	91.4		1022.3	1022.8	1021.5	148	296	30	2	23	0
Wed Sep 17 23:59:08 2008	3.4	0.0	12.8	19.3	8.6	82.3	94.1	56.9	1021.3	1022.9	1019.9	173	360	1	1	5	0
Thu Sep 18 23:59:08 2008	1.8	0.2	12.6	16.6	9.5	87.4	96.8	68.9	1021.4	1022.8	1020.8	127	360	1	2	8	0
Fri Sep 19 23:59:08 2008	1.2	0.0	14.7	18.6	12.0	84.5	94.6	30.2	1025.4	1028.1	1022.6	72	360	1	2	6	0
Sat Sep 20 23:59:08 2008	2.8	0.0	14.2	18.2	11.6	88.6	97.0	66.0	1026.9	1028.4	1024.3	253	360	1	2	6	0
Sun Sep 21 23:59:08 2008	1.5	0.0	13.7	20.3	10.7	86.1	97.3	44.3	1024.3	1027.2	1022.6	216	360	1	1	5	0
Mon Sep 22 23:59:08 2008	1.7	0.0	13.2	16.8	9.8	73.3	90.6	41.9	1027.7	1028.7	1026.8	179	360	1	3	9	0
Tue Sep 23 23:59:08 2008	2.8	0.0	12.5	18.9	8.6	80.9	94.6	49.4	1027.3	1028.3	1026.1	204	360	1	1	6	0
Wed Sep 24 23:59:07 2008	1.6	0.0	11.4	18.0	6.4	84.5	96.4	57.4	1027.3	1029.7	1026.2	185	360	1	1	5	0
Thu Sep 25 23:59:07 2008	1.5	0.2	12.5	18.5	7.6	88.2	96.4	67.9	1031.3	1033.0	1029.3	194	360	1	1	5	0
Fri Sep 26 23:59:07 2008	1.2	0.0	14.2	18.7	11.5	88.9	97.3	66.7	1032.1	1033.2	1031.1	281	360	1	2	5	0
Sat Sep 27 23:59:07 2008	1.4	0.0	12.7	18.4	7.3	85.6	96.9	61.0	1029.2	1031.1	1027.9	203	360	1	1	5	0
Sun Sep 28 23:59:07 2008	1.2	0.0	11.9	15.3	9.1	83.6	96.2	53.0	1026.8	1028.5	1025.6	120	360	1	2	8	0
Mon Sep 29 23:59:07 2008	1.6	0.0	11.6	15.7	7.2	80.0	93.2	62.3	1020.9	1025.8	1016.0	93	190	10	3	12	0
Tue Sep 30 23:59:08 2008	1.8	1.2	13.7	16.1	12.4	84.7	92.7	70.7	1008.0	1016.0	1002.4	86	360	1	5	15	1
Evap. & Rainfall Totals	**58.9**	**127.2**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Wed Oct 01 23:59:08 2008	1.8	2.0	11.2	14.0	8.3	75.7	88.4	57.5	1004.7	1006.4	1002.1	100	189	14	5	19	1
Thu Oct 02 23:59:08 2008	2.4	0.0	9.2	13.3	6.7	76.9	90.5	54.4	1009.0	1015.7	1005.7	115	213	17	4	23	1
Fri Oct 03 23:59:08 2008	2.2	0.0	8.9	13.3	5.6	74.3	87.7	53.6	1019.0	1020.7	1015.7	110	360	1	2	8	0
Sat Oct 04 23:59:08 2008	1.7	6.8	13.3	16.4	8.5	89.1	95.1	76.7	1003.7	1017.6	993.2	53	360	1	4	13	0
Sun Oct 05 23:59:07 2008	1.3	6.2	11.4	14.9	7.2	77.9	95.8	48.1	999.2	1005.1	990.3	199	360	1	3	10	0
Mon Oct 06 23:59:07 2008	2.0	3.8	13.5	15.6	11.0	92.2	96.6	76.9	1001.8	1004.7	997.5	214	360	1	3	11	0
Tue Oct 07 23:59:07 2008	1.1	8.8	12.0	14.7	8.2	88.6	96.7	67.1	999.7	1010.0	993.6	139	360	1	3	12	0
Wed Oct 08 23:59:07 2008	1.2	0.0	10.4	17.2	5.8	87.8	97.3	58.5	1017.7	1024.0	1010.0	151	360	1	1	5	0
Thu Oct 09 23:59:07 2008	1.1	1.4	12.8	15.0	5.8	91.7	97.6	86.9	1022.6	1023.9	1020.4	155	360	1	4	15	0
Fri Oct 10 23:59:07 2008	0.6	5.4	14.5	15.4	12.3	94.2	95.2	92.4	1019.1	1020.5	1018.1	77	360	1	5	17	0
Sat Oct 11 23:59:08 2008	0.6	0.0	12.7	15.9	8.7	90.5	97.1	71.0	1020.9	1022.6	1018.9	187	360	1	1	4	0
Sun Oct 12 23:59:08 2008	0.6	0.4	11.5	16.3	7.6	93.9	97.5	82.4	1018.6	1023.1	1014.7	159	360	1	1	5	0
Mon Oct 13 23:59:08 2008	0.6	0.2	14.4	17.7	12.3	89.2	95.5	74.6	1015.0	1016.9	1013.2	62	360	1	3	9	0
Tue Oct 14 23:59:08 2008	1.4	16.8	13.6	15.0	9.5	94.5	96.7	89.0	1012.9	1016.7	1010.0	111	360	1	3	10	0
Wed Oct 15 23:59:08 2008	0.5	1.0	10.4	13.9	7.2	88.5	94.4	76.5	1012.9	1014.5	1011.7	94	191	12	2	9	0
Thu Oct 16 23:59:08 2008	0.8	0.0	9.7	13.7	6.9	84.1	93.9	67.7	1017.6	1020.7	1014.4	104	207	25	2	8	0
Fri Oct 17 23:59:07 2008	1.1	0.0	8.9	13.5	5.2	88.5	96.7	66.3	1018.9	1020.5	1017.3	83	360	1	1	7	0
Sat Oct 18 23:59:07 2008	0.8	0.6	10.4	14.6	6.3	91.8	96.9	78.2	1015.7	1017.3	1014.6	86	360	1	2	10	0
Sun Oct 19 23:59:07 2008	0.7	3.0	13.2	14.2	11.9	88.9	95.2	76.8	1007.8	1015.0	1000.5	64	360	1	6	16	1
Mon Oct 20 23:59:07 2008	1.3	1.0	11.7	14.8	6.6	79.4	93.6	65.3	1000.1	1005.2	997.1	68	360	1	5	16	1
Tue Oct 21 23:59:07 2008	1.8	0.0	7.9	12.1	4.4	77.5	91.7	58.8	1010.8	1015.2	1005.2	83	355	10	3	11	0
Wed Oct 22 23:59:07 2008	1.5	0.0	9.9	14.5	4.5	83.3	95.9	60.9	1018.0	1020.1	1014.9	74	360	1	3	11	0
Thu Oct 23 23:59:08 2008	1.5	11.6	12.6	14.7	9.0	89.1	94.4	80.5	1008.8	1016.9	1002.8	62	360	1	6	20	1
Fri Oct 24 23:59:07 2008	1.2	0.0	9.4	13.6	5.0	77.5	89.3	56.1	1019.8	1025.1	1012.3	65	360	1	3	9	0
Sat Oct 25 23:59:08 2008	1.7	4.2	12.7	14.8	9.7	87.9	94.7	71.7	1017.6	1024.9	1012.7	62	360	1	5	17	1
Sun Oct 26 23:59:08 2008	1.5	1.8	11.2	14.3	6.7	80.7	93.9	52.8	1014.3	1015.5	1013.0	83	359	1	3	14	0
Mon Oct 27 23:59:08 2008	2.0	0.0	6.5	10.6	4.1	81.6	93.0	57.0	1013.5	1016.9	1011.1	120	302	14	3	12	0
Tue Oct 28 23:59:08 2008	1.4	0.4	5.1	9.2	1.3	81.7	93.2	65.2	1015.7	1018.4	1013.4	125	360	1	3	13	0
Wed Oct 29 23:59:07 2008	1.1	2.8	5.6	10.7	0.7	77.7	93.4		1004.8	1018.3	990.8	96	360	1	3	14	0
Thu Oct 30 23:59:07 2008	2.9	0.0	6.0	8.2	4.2	83.0	94.3	73.3	997.2	1008.7	988.9	171	302	45	4	13	0
Fri Oct 31 23:59:07 2008	0.9	0.0	5.5	9.5	2.6	75.0	87.5	4.0	1012.3	1014.2	1008.7	170	360	2	3	10	0
Evap. & Rainfall Totals	**41.2**	**78.2**															

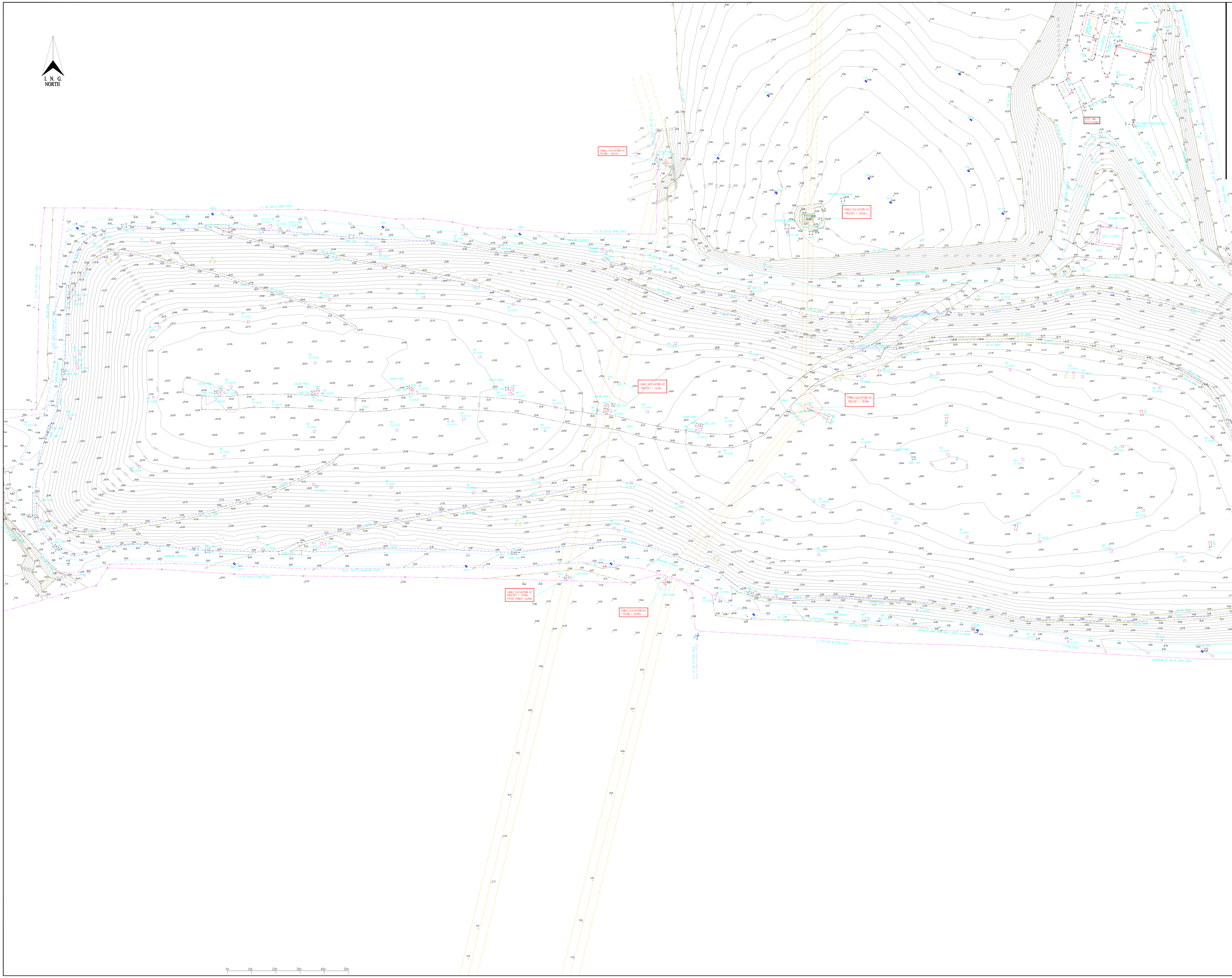
date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Sat Nov 01 23:59:07 2008	2.9	0.0	5.4	9.4	2.1	79.0	87.2	66.7	1013.9	1017.1	1012.7	149	360	1	3	10	0
Sun Nov 02 23:59:07 2008	1.2	0.0	7.7	12.1	4.4	81.3	91.6	68.1	1019.9	1021.4	1017.1	123	360	1	2	8	0
Mon Nov 03 23:59:07 2008	1.1	0.0	8.2	11.3	5.1	86.3	93.5	75.0	1018.4	1019.8	1017.4	156	360	1	2	9	0
Tue Nov 04 23:59:07 2008	0.8	0.0	8.0	10.1	4.4	88.9	95.1	82.8	1018.1	1019.1	1017.5	163	360	1	1	5	0
Wed Nov 05 23:59:07 2008	0.0	0.0	10.1	12.0	8.7	92.8	95.6	88.2	1019.2	1020.5	1016.8	241	360	1	1	2	0
Thu Nov 06 23:59:07 2008	0.2	20.8	10.3	12.2	8.0	94.1	96.7	87.3	1006.5	1016.8	997.1	261	360	1	3	16	0
Fri Nov 07 23:59:07 2008	0.5	6.2	9.6	11.8	7.4	83.2	94.2	58.3	996.9	999.1	993.7	92	360	1	6	17	0
Sat Nov 08 23:59:07 2008	1.9	10.0	9.2	12.5	4.6	85.6	94.0	73.5	995.7	1001.1	990.0	86	360	1	5	17	0
Sun Nov 09 23:59:07 2008	1.1	8.8	6.5	9.7	3.1	83.7	95.9	72.5	998.3	1001.9	994.2	63	360	1	5	15	0
Mon Nov 10 23:59:08 2008	1.0	3.2	7.5	10.3	4.9	79.5	92.1	64.2	996.8	999.4	995.0	63	360	1	4	14	0
Tue Nov 11 23:59:08 2008	1.3	0.8	8.3	11.5	5.4	81.5	94.2	63.9	1007.8	1014.0	998.1	89	186	4	4	14	0
Wed Nov 12 23:59:08 2008	1.4	0.0	7.5	11.6	4.2	88.4	96.0	71.2	1019.1	1021.5	1014.0	83	360	1	2	6	0
Thu Nov 13 23:59:08 2008	0.7	1.0	11.9	13.9	8.8	90.6	95.4	84.5	1020.2	1022.1	1018.3	66	360	1	2	6	0
Fri Nov 14 23:59:08 2008	0.6	0.0	12.2	13.0	10.9	88.4	93.2	81.9	1022.5	1023.6	1021.8	63	360	1	3	10	0
Sat Nov 15 23:59:08 2008	0.8	0.0	13.0	14.6	11.6	89.2	94.8	82.1	1024.7	1028.1	1021.8	68	360	1	4	10	1
Sun Nov 16 23:59:07 2008	0.9	0.0	12.2	14.6	10.5	90.0	94.4	80.0	1030.5	1033.1	1027.8	77	360	1	3	7	0
Mon Nov 17 23:59:07 2008	0.8	0.0	11.3	13.1	9.7	87.4	93.6	76.6	1024.0	1032.5	1017.3	73	360	1	4	16	0
Tue Nov 18 23:59:07 2008	1.1	0.0	10.3	12.1	9.0	84.7	91.8	75.6	1023.1	1027.3	1018.7	127	360	1	3	10	0
Wed Nov 19 23:59:07 2008	1.0	0.0	10.9	12.8	8.4	85.9	91.2	69.4	1025.8	1027.4	1023.5	115	194	15	4	13	1
Thu Nov 20 23:59:07 2009	0.7	0.0	12.7	13.6	12.0	83.9	89.0	79.0	1023.8	1027.3	1024.1	302	354	23	6	15	0
Fri Nov 21 23:59:07 2008	0.9	0.0	11.8	13.3	9.6	85.7	93.1	78.8	1022.9	1025.7	1020.7	123	197	28	5	17	1
Sat Nov 22 23:59:08 2008	1.1	0.0	11.3	13.2	9.9	85.1	94.2	73.2	1021.9	1025.1	1015.9	119	195	40	4	15	1
Sun Nov 23 23:59:08 2008	1.3	2.2	8.2	11.6	4.9	81.3	92.9	65.6	1004.9	1015.8	998.7	113	187	16	6	22	1
Mon Nov 24 23:59:08 2008	1.6	0.2	6.9	9.1	2.8	74.0	84.9	65.9	1008.8	1023.4	996.5	154	284	58	6	24	1
Tue Nov 25 23:59:08 2008	1.6	0.0	6.8	9.5	2.8	82.4	91.8	69.2	1027.8	1030.7	1023.2	123	360	3	3	9	0
Wed Nov 26 23:59:07 2008	0.9	0.0	10.5	12.7	9.1	83.1	91.5	62.4	1026.2	1030.3	1018.3	83	360	1	3	9	1
Thu Nov 27 23:59:07 2008	1.4	0.8	7.4	10.0	1.5	81.9	93.1	56.2	1007.9	1018.2	1000.4	74	360	1	4	13	0
Fri Nov 28 23:59:07 2008	1.4	0.0	1.9	6.7	-0.6	92.7	98.8	75.9	995.9	1000.5	994.1	126	360	1	1	4	0
Sat Nov 29 23:59:07 2008	0.2	0.2	1.7	5.2	-1.7	90.7	97.4	40.7	995.5	998.4	993.7	127	360	1	2	8	0
Sun Nov 30 23:59:07 2008	1.0	0.0	2.5	5.4	0.7	86.0	90.7	74.0	1001.8	1006.4	998.4	128	268	32	3	10	0
Evap. & Rainfall Totals	**31.6**	**54.2**															

date	EvapCalcDaily evap	PR_Sum24h PR_Sum24h	TA_24h Avg	TA_24h Max	TA_24h Min	RH_24h Avg	RH_24h Max	RH_24h Min	PA_24h Avg	PA_24h Max	PA_24h Min	WD_24h Avg	WD_24h Max	WD_24h Min	WS_24h Avg	WS_24h Max	WS_24h Min
Mon Dec 01 23:59:07 2008	0.6	0.0	3.2	6.3	0.4	86.0	92.5	73.4	1011.0	1014.8	1006.4	108	241	11	2	8	0
Tue Dec 02 23:59:07 2008	0.6	9.0	5.0	7.0	1.8	90.3	96.2	81.2	1004.6	1013.6	994.8	128	360	1	2	7	0
Wed Dec 03 23:59:08 2008	0.4	2.6	4.2	9.2	0.3	90.3	96.4	83.3	999.0	1004.8	983.2	114	360	1	3	14	0
Thu Dec 04 23:59:08 2008	0.4	4.4	6.7	10.0	4.6	84.0	94.5	72.3	979.6	983.1	976.9	83	360	1	5	22	1
Fri Dec 05 23:59:08 2008	1.0	0.2	7.8	9.4	5.7	80.4	90.2	69.7	993.3	1007.2	977.1	113	360	1	5	20	0
Sat Dec 06 23:59:08 2008	1.3	0.0	3.5	7.8	0.4	94.3	98.4	85.7	1014.2	1021.5	1007.2	187	360	1	1	6	0
Sun Dec 07 23:59:08 2008	0.2	0.0	4.9	8.1	1.4	93.3	98.4	81.3	1023.5	1025.3	1021.5	111	360	1	1	4	0
Mon Dec 08 23:59:07 2008	0.2	3.8	6.8	9.7	3.8	86.5	93.2	79.7	1020.3	1025.6	1017.0	102	360	1	3	11	0
Tue Dec 09 23:59:07 2008	0.6	0.0	4.9	8.1	2.8	85.6	93.2	72.2	1026.9	1028.6	1025.2	115	335	1	3	12	0
Wed Dec 10 23:59:07 2008	0.7	1.0	5.7	7.3	3.1	92.7	96.1	87.0	1021.6	1027.8	1014.2	102	360	1	2	6	0
Thu Dec 11 23:59:07 2008	0.2	0.8	6.1	7.5	4.7	95.3	97.4	87.8	1010.3	1014.2	1009.3	194	360	1	1	10	0
Fri Dec 12 23:59:07 2008	0.2	9.6	7.5	11.3	3.1	89.7	94.9	80.0	998.8	1011.2	986.9	91	360	1	4	16	0
Sat Dec 13 23:59:07 2008	0.7	0.0	2.9	5.4	0.9	88.8	94.9	77.4	987.5	991.9	985.9	98	360	1	2	7	0
Sun Dec 14 23:59:07 2008	0.4	0.0	3.0	5.9	0.7	84.8	92.5	74.5	1003.4	1015.0	991.9	121	360	1	3	11	0
Mon Dec 15 23:59:07 2008	0.4	0.6	4.3	9.3	0.2	90.6	96.3	82.6	1017.2	1019.7	1014.5	98	352	1	1	7	0
Tue Dec 16 23:59:07 2008	0.4	1.4	9.0	11.3	5.6	90.2	96.8	76.4	1009.9	1014.5	1006.5	73	360	1	4	12	0
Wed Dec 17 23:59:08 2008	0.8	0.0	7.1	11.1	2.0	87.5	95.0	78.4	1014.1	1015.7	1011.6	79	360	1	2	10	0
Thu Dec 18 23:59:08 2008	0.6	0.0	9.8	12.4	5.7	82.9	92.1	72.0	1015.2	1021.1	1012.9	69	360	1	4	13	1
Fri Dec 19 23:59:08 2008	1.2	0.2	8.8	12.1	2.1	86.6	93.2	77.3	1019.7	1022.3	1016.7	76	360	1	4	16	0
Sat Dec 20 23:59:08 2008	1.0	0.2	11.8	13.4	10.7	87.4	92.4	75.0	1023.9	1027.2	1019.9	62	360	1	5	13	1
Sun Dec 21 23:59:07 2008	1.3	0.0	11.7	12.9	10.8	89.9	91.9	88.1	1027.9	1031.3	1025.8	63	360	1	5	13	1
Mon Dec 22 23:59:07 2008	0.8	0.0	9.5	11.6	8.5	87.8	94.6	80.6	1031.6	1033.0	1030.7	159	360	1	3	8	0
Tue Dec 23 23:59:07 2008	0.7	0.0	8.6	9.3	7.5	84.4	91.4	80.3	1032.2	1033.7	1030.4	272	360	1	2	8	0
Wed Dec 24 23:59:07 2008	0.6	0.0	7.5	8.6	6.8	87.5	94.2	73.4	1032.0	1033.1	1030.8	251	360	1	1	5	0
Thu Dec 25 23:59:07 2008	0.3	0.0	8.1	8.8	5.3	79.1	90.4	72.8	1031.5	1033.0	1030.3	285	359	177	3	8	0
Fri Dec 26 23:59:07 2008	0.8	0.0	5.8	7.7	1.4	78.4	90.2	68.7	1033.7	1034.9	1032.6	255	342	96	2	9	0
Sat Dec 27 23:59:07 2008	0.8	0.0	3.8	7.9	1.1	81.4	92.6	66.0	1031.7	1034.2	1027.8	252	350	82	2	10	0
Sun Dec 28 23:59:08 2008	0.8	0.0	4.0	7.5	1.6	82.9	91.4	61.9	1024.8	1027.8	1022.9	261	341	27	3	12	0
Mon Dec 29 23:59:08 2008	1.0	0.0	5.9	7.5	4.9	75.5	81.1	69.5	1022.1	1023.3	1020.5	291	353	214	6	14	2
Tue Dec 30 23:59:08 2008	1.4	0.0	8.1	9.6	7.2	77.6	83.8	71.1	1022.8	1024.0	1021.8	300	360	1	6	12	2
Wed Dec 31 23:59:08 2008	1.5	0.0	7.9	8.5	7.1	80.4	84.5	68.9	1022.6	1023.5	1021.7	294	360	239	5	12	2
Evap. & Rainfall Totals	**22.0**	**33.8**															

Appendix E

Topographical Survey for East Cork Landfill

January 21st 2009



NOTES:

1. ALL LEVELS ARE IN METRES, UNLESS OTHERWISE STATED.
2. ANY DISCREPANCIES FOUND SHOULD BE REPORTED TO FOCUS SURVEYS LTD. AND ANY OTHER RELEVANT PARTIES.
3. THE COORDINATE SYSTEM IS BASED ON THE IRISH NATIONAL GRID.
4. ALL LEVELS ARE RELATED TO A SITE TBM WHICH IS A HILTI-NAIL SET IN THE FOOTPATH NORTH OF THE ADMINISTRATION BUILDING, ITS ELEVATION BEING 4.453m MALIN HEAD DATUM AS SHOWN ON THIS DRAWING.
5. LEVELS SHOWN RED ARE TO THE TOP OF BOREHOLE CASINGS.

LEGEND:

MH DENOTES MANHOLE
RIM DENOTES MANHOLE RIM ELEVATION
RG DENOTES ROAD GULLY
IC DENOTES INSPECTION COVER
SSF DENOTES SOD & STONE FENCE
BH DENOTES BOREHOLE
O/H DENOTES OVERHEAD
CP DENOTES CONTROL POINT
PGW DENOTES PROPOSED GAS WELL
GV DENOTES GAS VALVE
TB DENOTES TOP OF BANK
PO DENOTES PIPE OUTLET
V DENOTES VALVE
JB DENOTES JUNCTION BOX
BB DENOTES BOTTOM OF BANK

ZJ	22-01-09	SURVEY UPDATE OF CELLS 1 TO 10
ZI	13-01-08	SURVEY UPDATE OF CELLS 6 TO 10 AND PERIMETER ROAD
ZH	15-01-08	SURVEY UPDATE OF CELLS 1 TO 10
ZG	26-09-07	SURVEY UPDATE OF CELLS 6 TO 10 (GRADED FOR CAPPING CONTRACT)
ZF	15-06-07	SURVEY UPDATE OF CELLS 6 TO 10
ZE	10-01-07	SURVEY UPDATE OF CELLS 6 TO 10
ZD	12-09-06	CELLS 6 TO 10, EASTERN CAPPED AREA & STORMWATER LAGOON
ZC	07-06-06	SURVEY UPDATE OF CELLS 6 TO 10
ZB	15-12-05	SURVEY UPDATE OF CELLS 1 TO 10
ZA	12-07-05	SURVEY UPDATE OF CELLS 6 TO 10
Z	11-02-04	SURVEY UPDATE OF CELLS 6 TO 10
Y	16-08-04	SURVEY OF CELLS 6 TO 10 & GAS WELLS ETC CELLS 1 TO 4
X	24-03-04	SURVEY OF ACTIVE AREA, CELLS 8 & 9
W	19-03-04	SURVEY OF CAPPED AREA & ENVIRONS AT CELLS 1 TO 4
V	27-11-03	SURVEY OF CELLS 5 TO 10
U	03-10-03	ESB CABLE ELEVATIONS
T	26-06-03	SURVEY OF ESB POLES/PYLONS ENVIRONS
REVISION	REVISION DATE	DESCRIPTION OF REVISION

FOCUS

Focus Surveys Ltd., O'Connell Avenue, Turner's Cross, Cork.
Tel : 021-4314555 Fax : 021-4975907 e-mail : focussurveys@eircom.net

THE IRISH INSTITUTION OF SURVEYORS #230

TITLE

TOPOGRAPHICAL SITE SURVEY

SURVEY LOCATION

ROSSMORE LANDFILL,
CARRIGTWOHILL, Co. CORK.

CLIENT

CORK COUNTY COUNCIL.

SCALE	1:500
SURVEYED BY	E.D.
DATE OF ORIGINAL SURVEY	JUNE 1997
FIRST FOCUS REVISION	30-06-00
DRAWN BY	E.D.
CHECKED BY	D.C.

DRAWING NAME REV. ZJ

00-023_1

Appendix F

Ambient Noise Survey 2008

Annual Ambient Noise Survey Report

at

EAST CORK LANDFILL SITE,
ROSSMORE,
CARRIGTWOHILL,
COUNTY CORK.

EPA Waste Licence Ref. No: W0022-1

Prepared by:-

Cork County Councils,
Environmental Dept.,
Inniscarra Waterworks,
Inniscarra,
County Cork.

Nov 2008

Comhairle Contae Chorcai
Cork County Council,
Environmental Dept,
Test Report,
Inniscarra Waterworks,
Inniscarra,
County Cork.
Phone: (021) 4532700
Fax: (021) 4522777

Report Ref. No:S005

Report Issued To: Ms. Lisa Collins,
Envir. Officer,
East Cork Landfill,
Rossmore,
Carrigtwohill,
Co. Cork.

Sampling Locn.: East Cork Landfill Site **Waste Licence Ref :**W0022-1

Address: Rossmore, Carrigtwohill, Co. Cork.

This report relates only to this item.

Report By:_____ **Date:**_____
Andrew Mc Donnell,
Executive Scientist

CONTENTS

1. INTRODUCTION

1.1. A noise survey was conducted at East Cork Landfill site, Rossmore, Carrigtwohill, Co. Cork on 21st July and 29th August 2008 by the Environmental Dept. of Cork County Council.

The aim of the survey was to assess the noise impact at six locations in the vicinity of the landfill site and to determine if recorded levels were in compliance with noise limits specified in Waste licence (Ref No.:W0022-1), which pertains to this facility.

The landfill site was not operational for the collection of waste throughout the survey periods.

The weather during the monitoring periods was dry and sunny with wind speed measured at < 2m/s from a North Westerly direction on 21st July and South/South Easterly direction on 29th August 2008.

The temperature during the monitoring periods varied between 17 ^{o}C and 20^{o}C

The instrumentation was manned throughout the sampling intervals and comments were recorded in order to aid the interpretation of results.

2. LOCATION

2.1. The East Cork landfill site is located to the south of Rossmore Bay, Rossmore, Carrigtwohill, Co. Cork. The site is surrounded by agricultural land on a peninsula jutting out into the North Channel of Cork Harbour.

2.2. As required by Schedule F of waste licence ref no: W0022-1, five noise monitoring locations were identified and one noise sensitive location. The locations of the stations are outlined in Table 2 and indicated in figure 4.1.

Table 2.1 Noise Monitoring Stations

MONITORING LOCATION.	***Location***
GG4	This monitoring location is located on the southern end of the site.
GG1	This monitoring location is located on the north western end of the site.
N4	This monitoring location is located next to the entrance gate directly to the north of the landfill site.
N5	This location is located at the north western boundary of the site. The landfill site is not visible from this location
N3	This location is to the east of the landfill with a line of sight to the bay. The landfill site is not visible from this location.
N1 (Noise sensitive location)	This noise sensitive location is a residential house. The landfill site is not visible from this monitoring location.

3. NOISE SURVEY

3.1. The noise survey was conducted on 21st July and 29th August 2008. The landfill site was not operational for the collection of waste during the monitoring periods.

3.2. The weather during the monitoring periods was dry and sunny with wind speed measured at < 2m/s from a North Westerly direction on 21st July and South/South Easterly direction on 29th August 2008.

3.3. The survey was carried out using a Bruel & Kjaer 2260 sound level meter with enhanced sound analysis BZ7202. The instrument was calibrated before and after the survey using a known pure tone noise source. Following completion of the survey recorded data was uploaded to the computer for subsequent analysis using Bruel and Kjaer evaluator type 7820 software.

Table 3.1

Equipment	Monitor	Bruel & Kjaer type 2260 Serial Number:2001683 *Certificate of Calibration issued by*: Bruel & Kjaer UK Ltd *Certificate Number*: 16710
	Application Module	Enhanced Sound Analysis BZ7202
	Microphone	Bruel & Kjaer type:4189 Serial Number: 2021258
	Time Weight.	Fast
	Freq. Weight.	'A' and 'L'
	Calibrator	Bruel & Kjaer type: 4231 Serial Number: 2094795 *Certificate of Calibration Issued by*: Bruel & Kjaer UK Ltd. *Certificate Number*: 16703
	Software	Bruel & Kjaer Evaluator type 7820 version 4.3

3.4. 30 minute monitoring levels were recorded at stations GG4, GG1, N4, N5, N3 and Noise sensitive location N1. (See figure 4.1)

3.5. All measurements were made in accordance with *“ International standards organisation ISO 1996. Acoustics-description and measurement of Environmental noise Parts 1, 2 and 3”*

4.0 NOISE SURVEY RESULTS – Arising from ambient noise monitoring conducted on 21st July and 29th August 2008.

Sampling Results

Table 4.1

Sampling Date	Sampling Location	Sampling Interval	L_{Aeq} (dB)	L_{A90} (dB)	L_{A10} (dB)	Sampling Notes
29/8/08	**GG4**	1156-1226	33	30	34	During the monitoring period no noise was audible from the landfill site. The general noise during the monitoring period was background rural noise with birds singing. Plane noise 12:08.
21/7/08	**GG1**	1454-1524	47	41	48	The dominant noise source at this location was noise from adjacent quarry. 14:54 & 15:04 plane noise overhead. 15:23 onwards noise audible from tractor cutting hay in adjacent field. Intermittant noise from birdsong in the vicinity of the monitoring location. No noise audible from Landfill site.
21/7/08	**N4**	1300-1330	53	38	56	The dominant noise at this location was noise from vehicles entering and leaving the adjacent civic amenity site. Intermittant noise also from people talking, birdsong in the vicinity of the monitoring Location. 1 plane passed overhead during monitoring period at 13:14. No noise audible from landfill site.

4.1 Sampling Results ctd:

Table 4.1 ctd:

Sampling Date	Sampling Location	Sampling Interval	L_{Aeq} (dB)	L_{A90} (dB)	L_{A10} (dB)	Sampling Notes
29/8/08	**N5**	1235-1305	47	41	45	During the monitoring period noise was audible from an adjacent quarry. Noise also audible intermittently from road traffic entering the civic amenity site. No noise audible from landfill site.
29/8/08	**N3**	1314-1344	45	33	44	During the monitoring period noise was audible from adjacent quarry. 3 cars passed monitoring location during monitoring period. Plane noise at 1330 hours. Background rural noise with birds singing. No noise audible from Landfill site.
29/8/08	**N1 (Noise sensitive location)**	1356-1426	37	28	40	No noise from the landfill was audible at this location. The predominant noise was background rural noise with birds singing.

4.2 Sampling Results – 1/3 Octave frequency levels

Table 4.2

Ref. N°.	Sampling Location	Octave bands (Hz) Sound Pressure Levels dB (unweighted) per band									L_{Aeq} (dB)	L_{A90} (dB)	L_{A10} (dB)
		31.5	63	125	250	500	1k	2k	4k	8k			
1	GG4	49	48	37	27	22	15	12	7	9	33	30	34
2	GG1	53	51	44	41	39	38	33	25	20	47	41	48
3	N4	58	61	54	47	46	41	39	34	28	53	38	56
4	N5	55	58	50	41	36	34	29	32	30	47	41	45
5	N3	57	58	42	39	35	35	33	28	27	45	33	44
6	N1	51	47	39	27	28	23	23	25	20	37	28	40

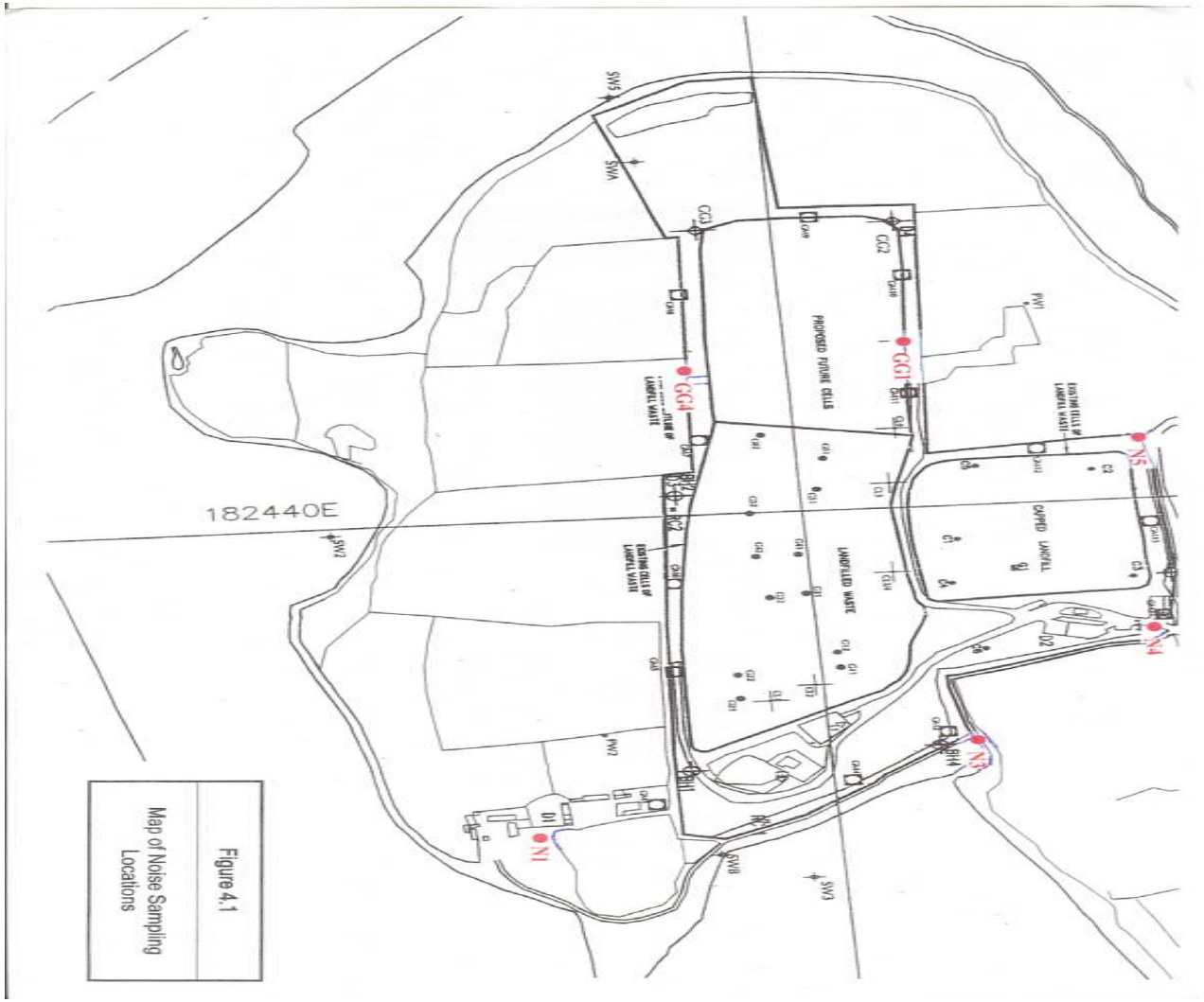
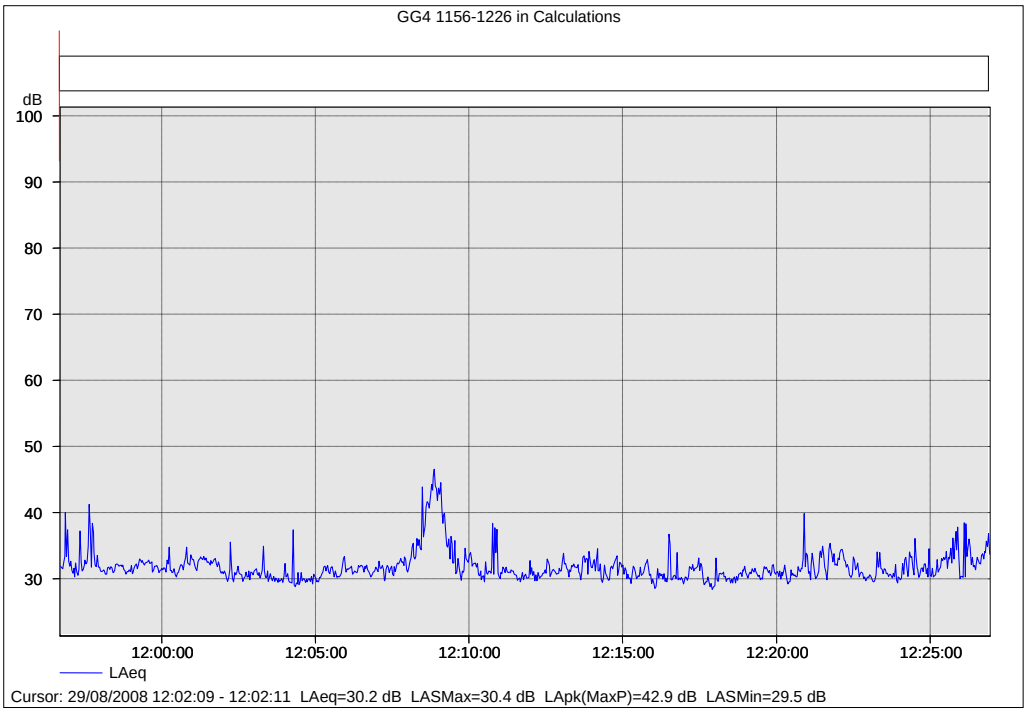


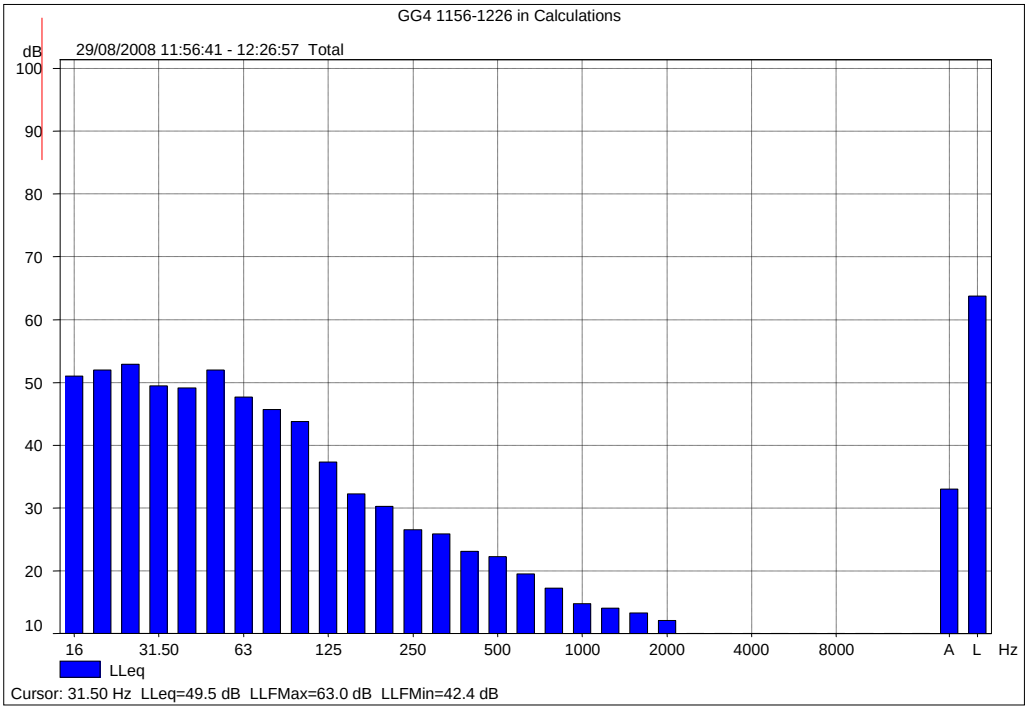
Figure 4.1

Map of Noise Sampling Locations

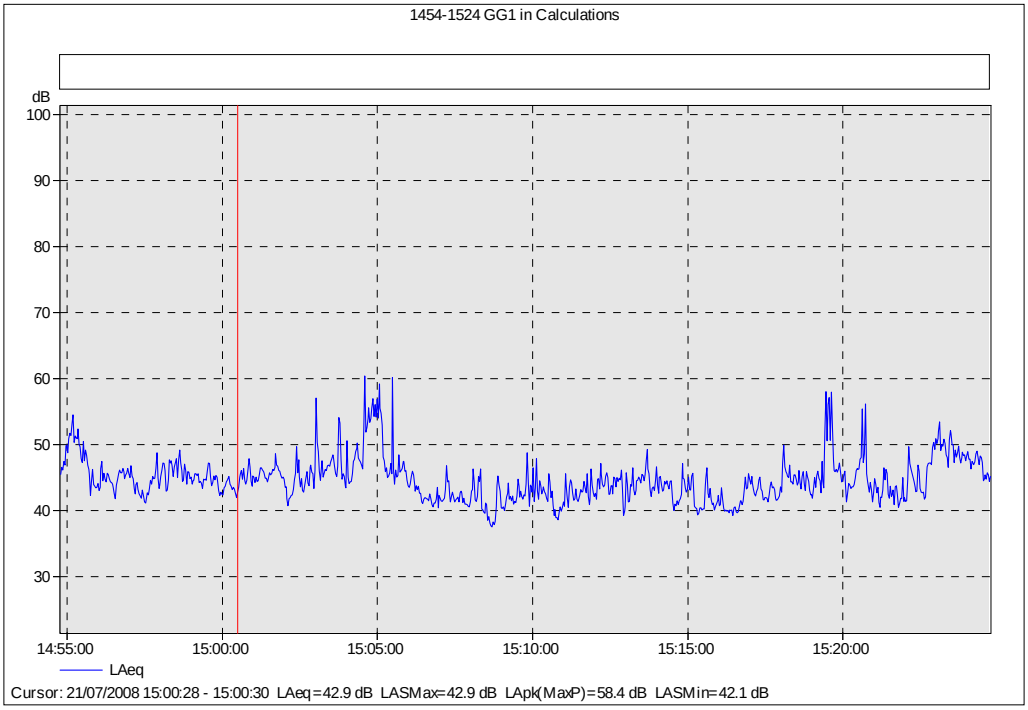
NOISE PROFILES & FREQUENCY SPECTRUMS

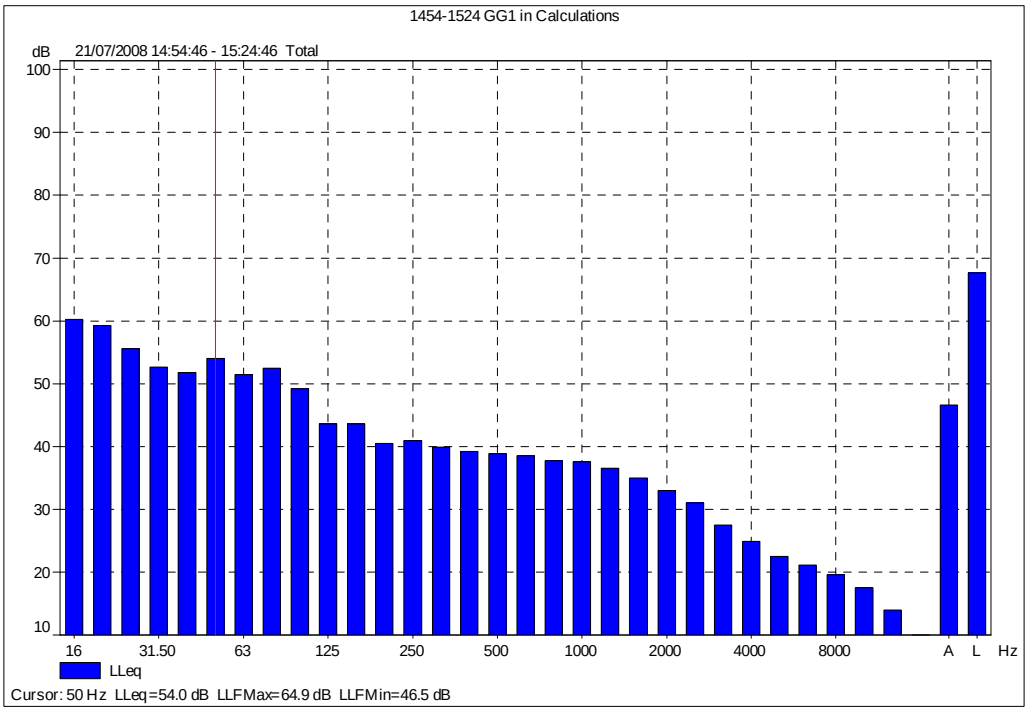
4.2.1 – Sampling Location GG4



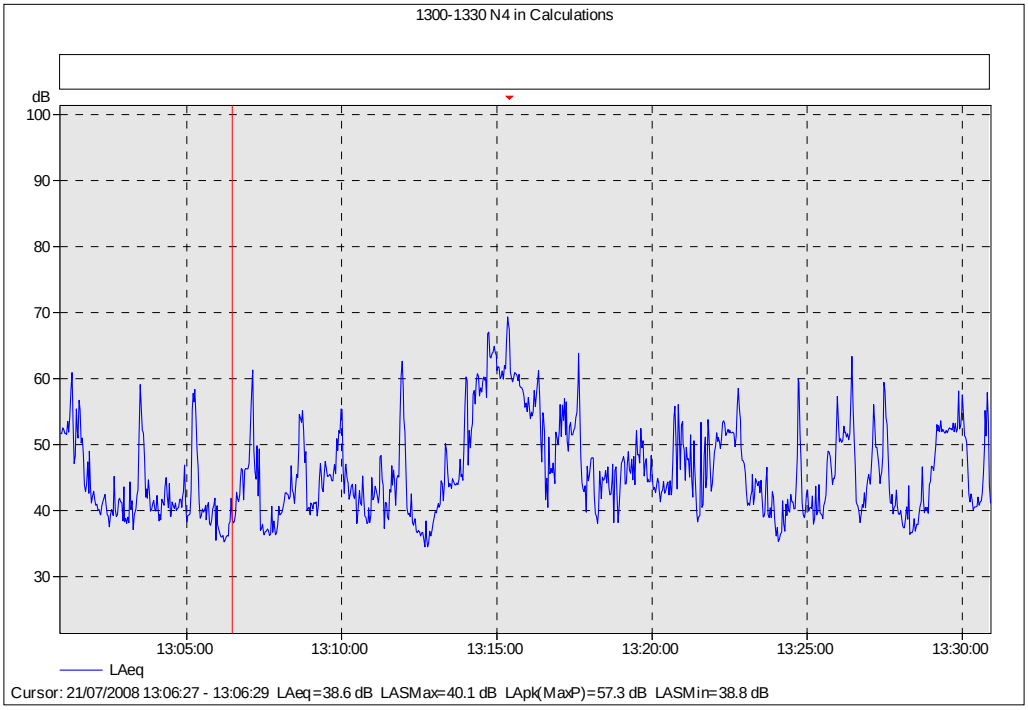


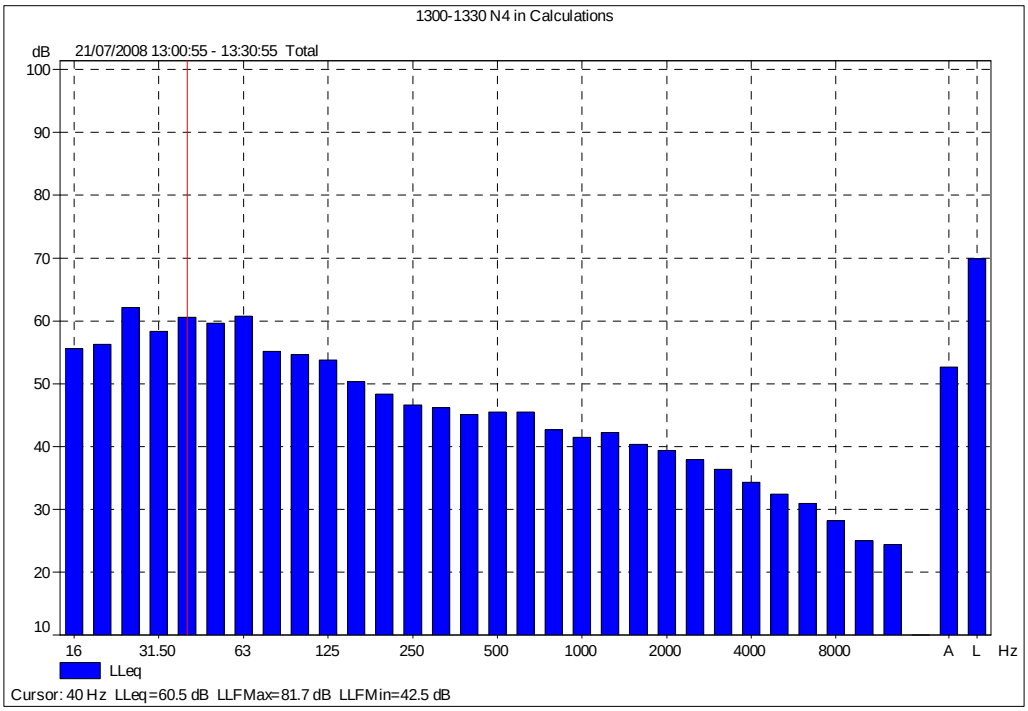
4.2.1 – Sampling Location GG1





4.2.1 – Sampling Location N4





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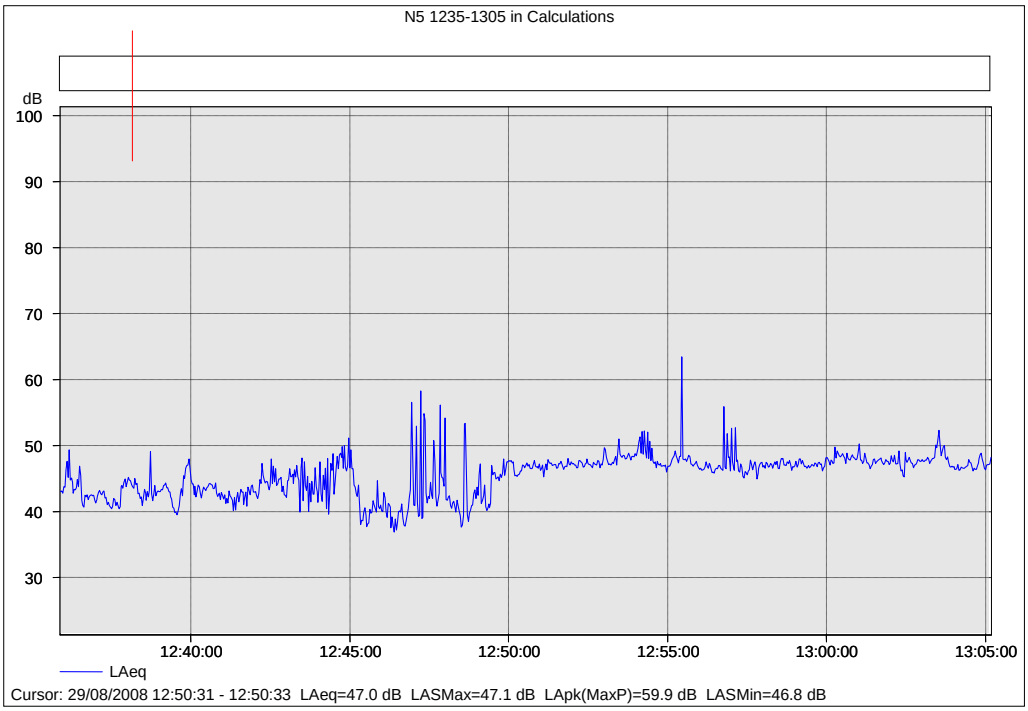

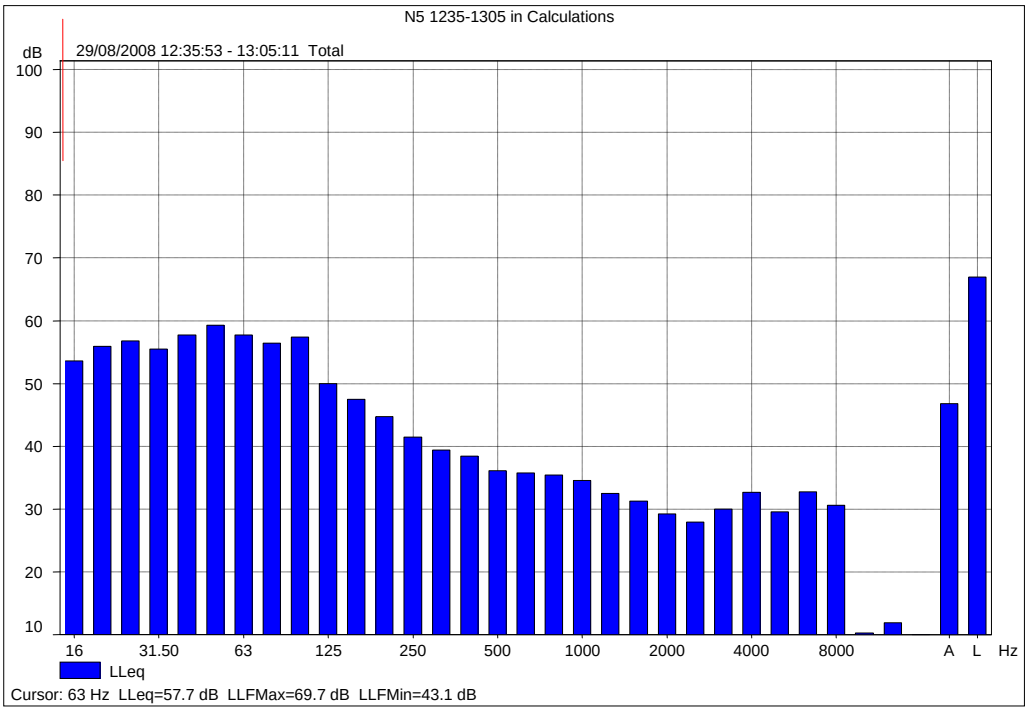

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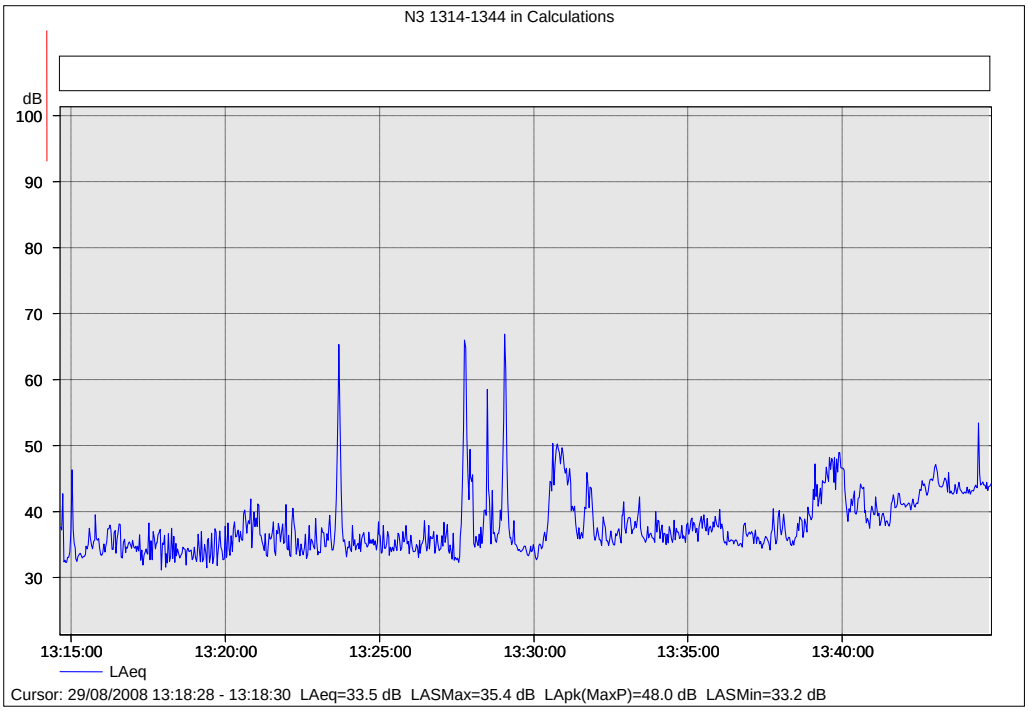
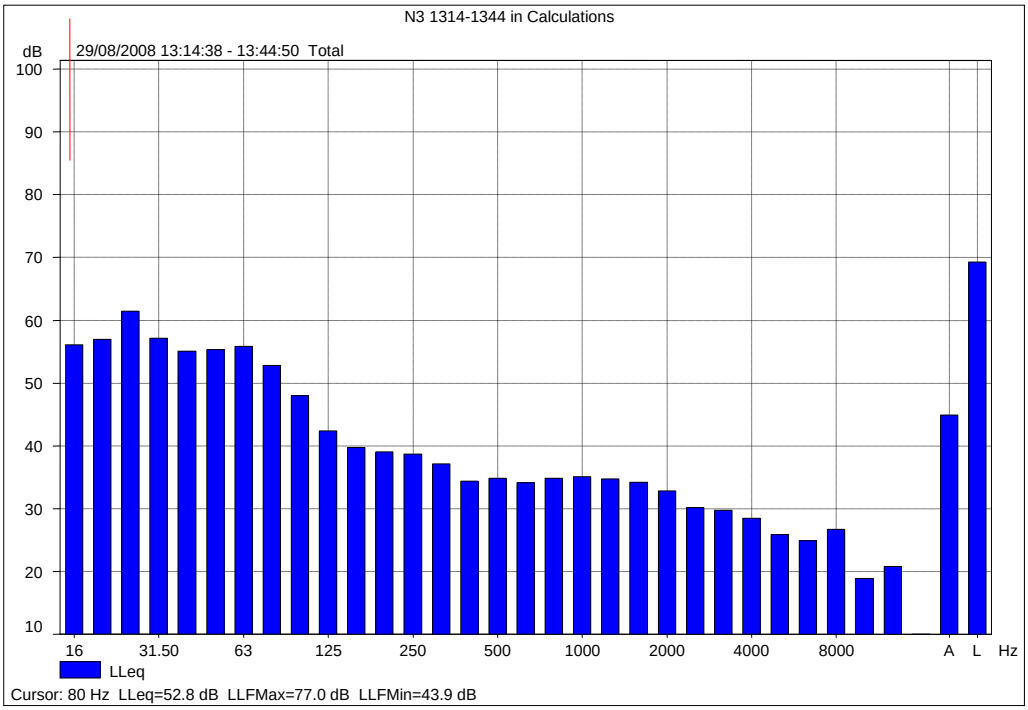
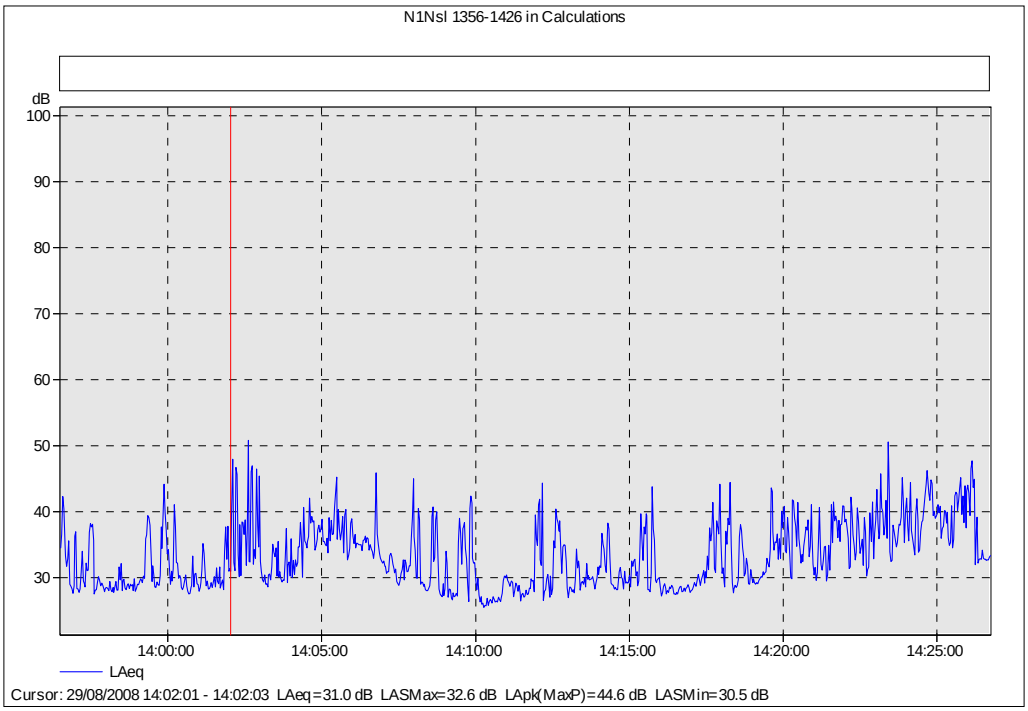
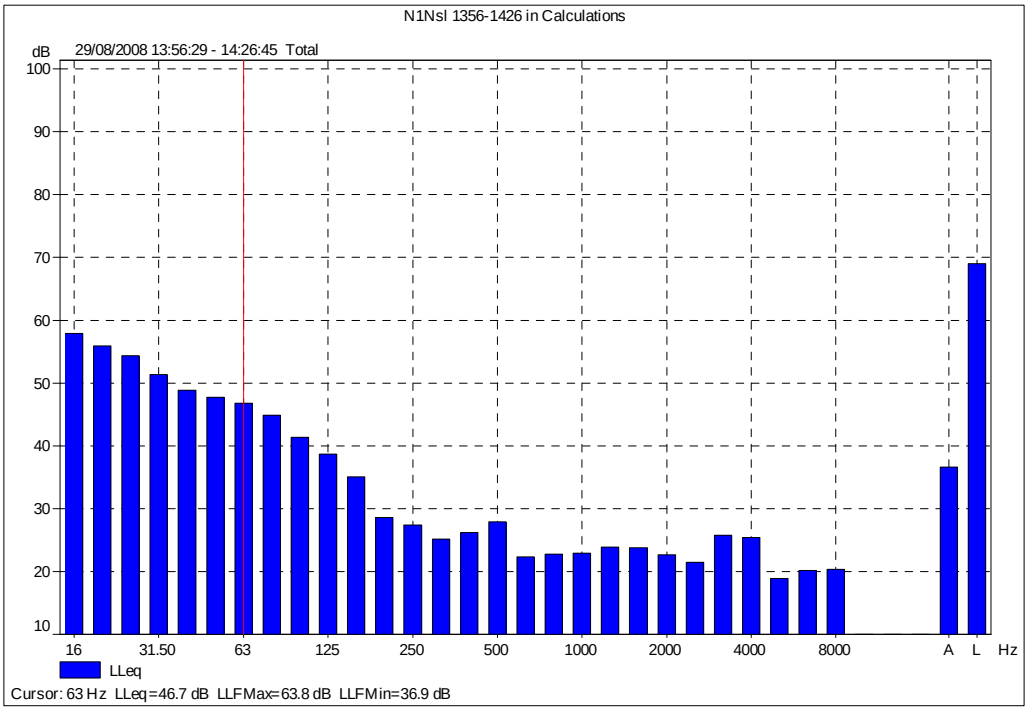




4.2.1 – Sampling Location N1 (Noise Sensitive Location)





5. DISCUSSION

5.1 Boundary Locations - Daytime monitoring

Noise levels recorded at boundary location GG4 (33 L_{Aeq}), GG1 (47 L_{Aeq}) , N4 (53 L_{Aeq}), N5 (47 L_{Aeq}), N3 (45 L_{Aeq}) and noise sensitive location **N1** (37 L_{Aeq}), were in compliance with the daytime 55 dB(A) (L_{Aeq}) limit specified in Schedule G of waste licence ref no. (W0022-1) for the East Cork Landfill site.

5.1.2 Noise Sensitive Location (NS1)

The nearest residence is located to the south of the landfill site. The noise levels recorded at this location indicated a L_{Aeq} level of 37 dB(A). This level is in compliance with the daytime licence limit stipulated for the facility. No noise was audible from the landfill site during the monitoring period. The predominant noise was background rural noise with birds singing.

5.1.3 Night-Time Compliance

The facility is closed during night-time hours and does not contribute to noise levels in the area.

5.1.4 Tonal and Impulsive Compliance

No tonal components arising from the site under investigation were audible subjectively or identified by 1/3 octave band analysis during the monitoring intervals.

No impulsive components were noted during the monitoring intervals

5.1.5. Comparison of recorded noise levels 2003 -2008

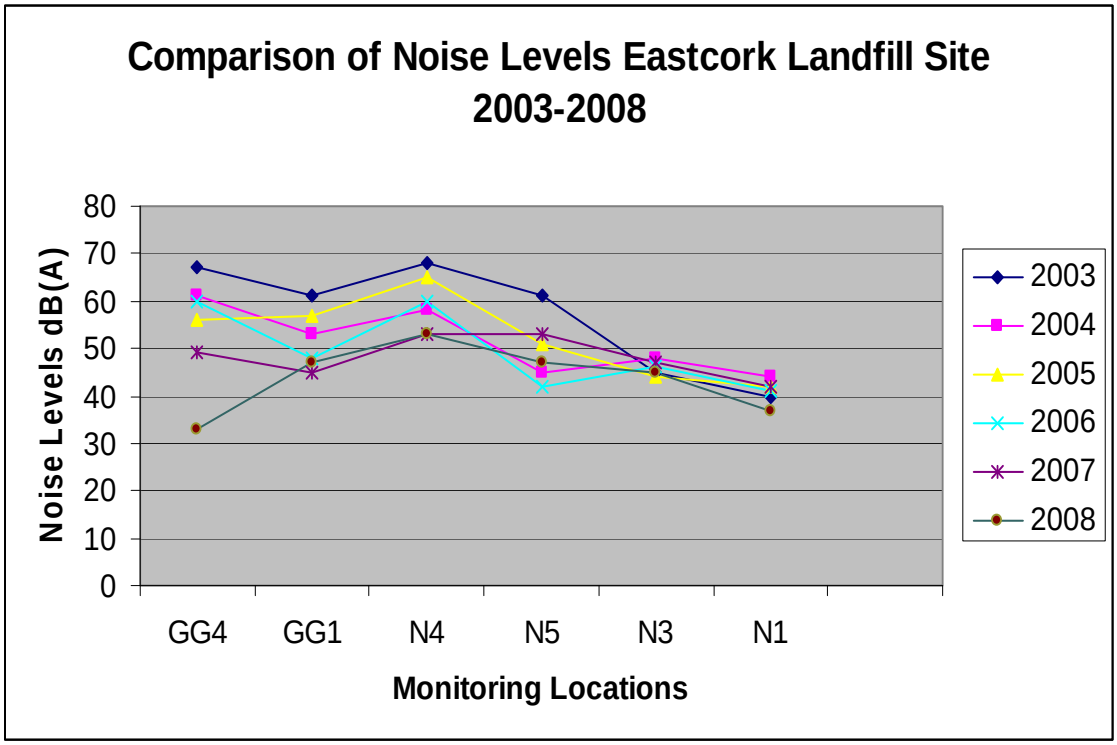


Figure 5.1

Table 5.1

Recorded Noise Levels L_{eq} dB (A)	GG4	GG1	N4	N5	N3	N1
2003	67	61	68	61	45	40
2004	61	53	58	45	48	44
2005	56	57	65	51	46	42
2006	60	48	60	42	46	41
2007	49	45	53	53	47	42
2008	33	47	53	47	45	37

6. CONCLUSION

The results of the noise monitoring survey indicated compliance with noise emission limit values for the facility stipulated in Schedule G of Waste Licence (Ref. No. W 0022-1) at each of the six noise monitoring locations.

Appendix G

Ecology Monitoring Report

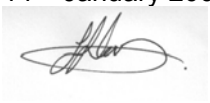
LIMOSA ENVIRONMENTAL
ECOLOGICAL AND ENVIRONMENTAL CONSULTANCY

Ecological Monitoring of East Cork Landfill

Report for

Cork County Council

December 2008

Report Reference:	RP08-GW007-04-0
Draft	Final Report
Prepared by:	Dr Lesley J. Lewis.
Checked by:	Dr Lesley J. Lewis.
Report Date:	19th December 2008
Sign-off date:	14th January 2009
Signature:	

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EXECUTIVE SUMMARY

This report presents the results of the 2008 ecological surveys and monitoring undertaken across East Cork Landfill and environs, in fulfilment of the requirements of the East Cork Landfill Waste Licence.

East Cork Landfill is situated 2.5km south of Carrigtohill, Co Cork and lies on the Rossmore Peninsula; a small peninsula that extends into the North Channel of Cork Harbour. The extensive coastal and intertidal habitats that occur around the peninsula are afforded conservation protection under two pieces of EU legislation (EU Habitats Directive and EU Birds Directive).

Ecological surveys and assessment include terrestrial habitats, flora and fauna, intertidal habitats (mudflats and mixed substrata shoreline), an assessment of the waterbird communities of the surrounding harbour area and a review of shellfish monitoring and water quality data.

In 2008, we report that the habitats outside of the landfill site continue to support a diversity of flora and fauna. A comparison of current habitat survey results with data collected in 1998 suggests that habitats outside the landfill boundary have changed little in the ten-year period. The majority of habitats inside the landfill boundaries are artificial or modified in nature and subject to on-going disturbance as a result of the rehabilitation process now underway since the landfill's closure in 2007. This report gives recommendations with regards site rehabilitation and the management and removal of the alien, invasive plant species Japanese Knotweed.

The intertidal survey (benthic flora and fauna) recorded communities consistent with previous annual surveys. Comparison of data both over a short time period (three years) and a longer time period (seven years) suggests that the intertidal flora and fauna communities of the study area have remained largely stable. The combination of both a mixed substrata shoreline and soft sediment habitats results in the study area recording a good diversity of benthic flora and fauna and there is a trend for increasing diversity over the past two years.

Waterbird numbers within the two survey zones A and B (Rossmore Bay and Brick Island Embayment) show great variation across the years although some species appear to have relatively stable wintering populations (e.g. Redshank). However, this year the data review suggests a decline in numbers of Black-tailed godwits and Curlew in recent years. These trends should be investigated in future years but the causes of possible declines are difficult to predict as so many factors may play a part in population demographics including factors in other parts of the species' range (e.g. the breeding grounds). Curlews are also showing a national trend for decline. In contrast numbers of wintering Dunlin within the study area appear to have increased. Interestingly within the North Channel as a whole numbers of Black-tailed godwits, Dunlin and Curlew show a trend for decline. Supporting over a quarter of the total waterbirds that winter in Cork Harbour, the North Channel is an important part of the overall wetland site of Cork Harbour. Review of data across the years shows that the importance of the North Channel, relative to the entire coastal complex of Cork Harbour, has remained relatively stable.

Results of sediment chemistry analysis suggest that levels of organic enrichment have decreased within recent years and particularly within the last 12 months. This result is in line with general improvements in water quality in the North Channel in recent years. In terms of metals analysis, no result stood out in terms of a particularly high level. Comparison of results across recent years reveals how metal levels can be highly variable between years.

Data for trace metal concentrations in shellfish within the North Channel were obtained from the Marine Institute and compared with the available reference limits. All data were within the accepted guidance limits. Estuarine water quality data for the North Channel shows several elevated readings in recent years (e.g. DIN, $NH_{3.}$). Total Ammonia appears to be the water quality parameter that is exceeded the most and at more than one station.

Anthropogenic sources of contaminants to seawater include sewage, industrial effluents and fertilizer run-off and it is not possible to link elevated levels within the North Channel to landfill activity as there are so many other confounding variables (i.e. other possible pollution sources). However, in general water quality has improved in recent years, the North Channel retaining an improved classification of 'intermediate' across EPA assessment periods 1999 – 2003 and 2002 – 2006.

Overall the results of recent annual ecological surveys present no evidence to suggest that East Cork Landfill site has had any deleterious effects on the flora and fauna of the terrestrial and coastal habitats of Rossmore Peninsula.

1.0 INTRODUCTION

1.1 Background

Limosa Environmental was commissioned by Cork County Council to undertake ecological surveys for East Cork Landfill during 2008 in fulfilment of the requirements of the East Cork Landfill Waste Licence (Environmental Protection Agency Reg. No. 22-1, Condition 9.14):

Condition 9.14 Ecological Monitoring

Condition 9.14.1 *''The licensee shall submit to the Agency for its agreement within six months of the date of grant of this licence, proposals for the ongoing monitoring and assessment of the site and the adjoining habitats (including methods) with particular reference to the intertidal habitats (shoreline and mudflats). The scope of these proposals shall take into account the findings of the investigations required by Condition 9.13 and shall include as a minimum, monitoring of the following:*

(i) habitat quality within the Special Protection Area and proposed NHA including the usage of the intertidal areas by estuarine birds and an assessment of the relative importance of the area within the Cork Harbour SPA;

(ii) estuarine water quality and chemical analysis of estuarine sediments;

(iii) flora including macroalgae; and

(iv) macroinvertebrate fauna (including bivalves) of sediments and shoreline (hard substrate).

In addition to the above, a summary and interpretation of the significance of the results of monitoring of the shellfish growing areas in the vicinity of the landfill undertaken by the Department of the Marine and Natural Resources/Marine Institute shall be submitted to the Agency along with the Annual Ecological Report required to be submitted in accordance with schedule D: Recording and Reporting to the Agency.''

1.2 Scope of works

In fulfilment of the waste licence conditions, and following the tender brief issued by Cork County Council, the scope of works for the 2008 surveys is as follows:

- Phase 1 habitat survey of terrestrial components of the site following the 'Habitat classification of Ireland' (Fossitt, 2000). Assessment of changes in habitats and species of flora and fauna since the baseline survey of 1998.
- Intertidal survey to include estuarine sediments and shoreline; macroalgae and *Spartina* sp. distribution.
- Waterbird surveys of the intertidal mudflats surrounding Rossmore Peninsula. Assessment of the waterbird data and the relative importance of the North Channel within Cork Harbour SPA.
- Chemical analysis of estuarine sediments at pre-determined sampling points and following strict criteria as set out in the tender brief.
- Collection, collation and interpretation of EPA water quality data for the North Channel.
- Collection, collation and interpretation of shellfish monitoring data as collected by the Department of Communications, Marine & Natural Resources – Note the regulatory body has now changed and data is obtained from the Marine Institute).
- Consultation with the National Parks & Wildlife Service with regards any recent surveys or monitoring within the study area and to discuss recent trends in waterbird populations.

1.4 Report format

The 2008 report is divided into sections that correspond to the different areas of ecological surveys undertaken. Section 2 presents the results of the terrestrial habitat and botanical survey with notes on fauna (mammals and terrestrial birds) that were recorded within the study area throughout the year. Section 3 reports on the intertidal survey that includes macroinvertebrates, flora and sediment analysis. Section 4 provides an assessment of the wintering waterbird community of Rossmore Bay, the North Channel and Brick Island embayment. Section 5 reviews shellfish and water quality data for the study area and Section 6 reviews EPA water quality data for the North Channel.

Figure 1. Google Earth ™ aerial photograph of Rossmore Peninsula. The red arrow shows the location of East Cork Landfill.

2.0 TERRESTRIAL HABITAT AND BOTANICAL SURVEY OF EAST CORK LANDFILL AND ENVIRONS

2.1 Background & study area

East Cork Landfill is situated 2.5km south of Carrigtohill, Co Cork and lies on the Rossmore Peninsula; a small peninsula that extends into an area called the North Channel of Cork Harbour (Figure 1). The landfill covers approximately 1/3 of the total land area of the peninsula, the remaining land predominantly agricultural in nature.

The North Channel (Great Island Channel) stretches from Little Island to Midleton and is bordered by mainland to the north and east, Great Island to the south and Fota Island to the west. Receiving its main freshwater from the Owennacurra and Dungourney Rivers (NPWS, 2001), the North Channel is an integral part of Cork Harbour and is linked to inner Lough Mahon by the Belvelly Channel and to the outer harbour by the Ballynacorra River Channel.

East Cork Landfill closed for waste acceptance in February 2007 but an area of built surfaces in the north of the site is still operational as a civic amenity centre.

2.1.1 Designated areas in the vicinity of the study area

The North Channel is one of the most important areas within Cork Harbour in terms of its conservation value. The North Channel forms part of the Great Island Channel candidate Special Area of Conservation (cSAC) (EU Habitats Directive 92/43/EEC) (Site Code 1058) and contains several habitats that are listed on Annex I of the directive including mudflats and sandflats not covered by seawater at low tide (Code 1140). The SAC site synopsis (National Parks and Wildlife Service NPWS) is presented in Appendix 2.1.

The North Channel also forms an integral part of the Cork Harbour candidate Special Protection Area (cSPA) (Site Code 4030), an EU designation in recognition of areas of international importance for waterbirds (EU Birds Directive 79/409/EEC). The SPA site synopsis (NPWS) is presented in Appendix 2.1.

A similar area to the Cork Harbour SPA is also designated as a Ramsar Site (Site Code 835) (Ramsar Convention Bureau, 1984).

2.2 Habitat Survey

2.2.1 Methods

The habitat survey area comprised East Cork Landfill site and the surrounding terrestrial and coastal environment of Rossmore Peninsula.

The habitat survey was conducted on June 25th 2008 following methodology described in '*Draft Habitat Survey Guidelines'* (Heritage Council, 2002). Habitats were classified using habitat descriptions and codes set out in the Heritage Council's "*A Guide to Habitats in Ireland*" (Fossitt, 2000).

Vascular plant species lists were compiled for habitats recorded within the landfill site and the majority of habitats in the surrounding study area, the exception being some areas of agricultural land which were either (1) privately owned, (2) full of arable crops or (3) contained livestock. Target notes were made for habitats encountered including notes on dominant vegetation and an assessment of habitat change since the 2007 survey.

Throughout the text, common names are used for plant species. A list of vascular plants is presented in Appendix 2.2, with species Latin names and plant frequency of occurrence within Ireland (after Webb et al. 1996). This table also lists the habitat(s) within which each plant species were recorded. A habitat map was produced and is shown in Figure 2.

2.3 Results

Terrestrial habitats are separated into those occurring within the landfill boundaries and those occurring within the surrounding environment. Saltmarsh habitats are included here as they form the transition between land and sea. Intertidal habitats are considered in Section 3.

Landfill Habitats

The landfill site comprises four main habitats: **spoil and bare ground**, **recolonising bare ground**, **buildings and artificial surfaces**, and **semi-natural grassland. Dry meadows and grassy verges**, a**menity grassland, scrub, artificial ponds (FL8), hedgerows and treelines** are also present.

The landfill site is approached from a local road from the north and this enters into the main 'built' area of the site which includes buildings and concreted areas in association with the civic amenity area. This man-made habitat is classified as **buildings and artificial surfaces (BL3).**

Alongside the built area is a small patch of **amenity grassland (GA2)** with a sward kept short by regular mowing. Grass species dominate the sward although a variety of herbs were also recorded such as Daisy, Dandelion, Ragwort, Ribwort Plantain and Yarrow.

Between the amenity grassland and the landfill boundary fence is a dense patch of bramble **scrub (WS1),** which has remained relatively unchanged in recent years and supports breeding birds such as Dunnock.

Directly south of the built area is a small raised area of vegetation where the landfill track splits to go to the east and west. More densely vegetated in 2008 compared with 2007, this small patch was classified as **dry meadows and grassy verges (GS2**), a habitat most often associated with roadside verges (Fossitt, 2000). Grass species False Oat-grass and Cock's-foot dominated along with broadleaved herbs such as Ragwort, Smooth Sow-thistle and Tormentil. This habitat continues as a thin linear strip along the base of the capped area to the south-east although it is too small to be shown on the habitat map.

The eastern boundary of the landfill site comprises a fence with cover of **scrub (WS1)** and/or **hedgerow (WL1)** habitats. In June 2008, a track leading south-east from the built area opened into a wider area of **spoil and bare ground (ED2).** This habitat also continued along the landfill perimeter in the south (spoil track). At the time of survey, these areas appeared recently cleared and were in the process of being converted into a site road. The recent disturbance of topsoil inevitably meant that little vegetation was supported by this habitat hence the ED2 classification, which refers to bare areas that are transient in nature and subject to on-going disturbance (Fossitt, 2000).

In places were spoil had been banked up (e.g. around perimeter) some vegetation growth had occurred. Where vegetation cover is >50% the habitat category **recolonising bare ground (ED3)** applies. These areas were small and often too small to map. Species diversity in this habitat however was high with many colonising species such as Foxglove, Pineappleweed, Scarlet Pimpernell, Sun spurge and Common Fumitory.

The naturalised and non-native species Prickly Lettuce (*Lactuca serriola*) was recorded within this habitat (south-east of built area). This species was first recorded in Ireland in 1996 (Preston et al. 2002) and frequently occurs around the coast of Cork Harbour (L. J. Lewis *pers. obs*). It is not currently thought to be an aggressively invasive species.

The plant grows to >6ft in height and bears hard pointed spines.

The capped landfill area in the south-east of the landfill site had been recently stripped of vegetation at the time of survey and is therefore classified as **spoil & bare ground (ED2).** Abutting the eastern extent of this area is a fenced area containing two **artificial ponds (FL8).** The fence itself was covered thickly with bramble **scrub (WS1)** (Figure 2).

The western capped area within the landfill site was also classified as **spoil & bare ground (ED2)** in June 2008. Small patches of **recolonising bare ground (ED3)** occurred in places, particularly upon the sloping banks of the cap, but were often too small too map.

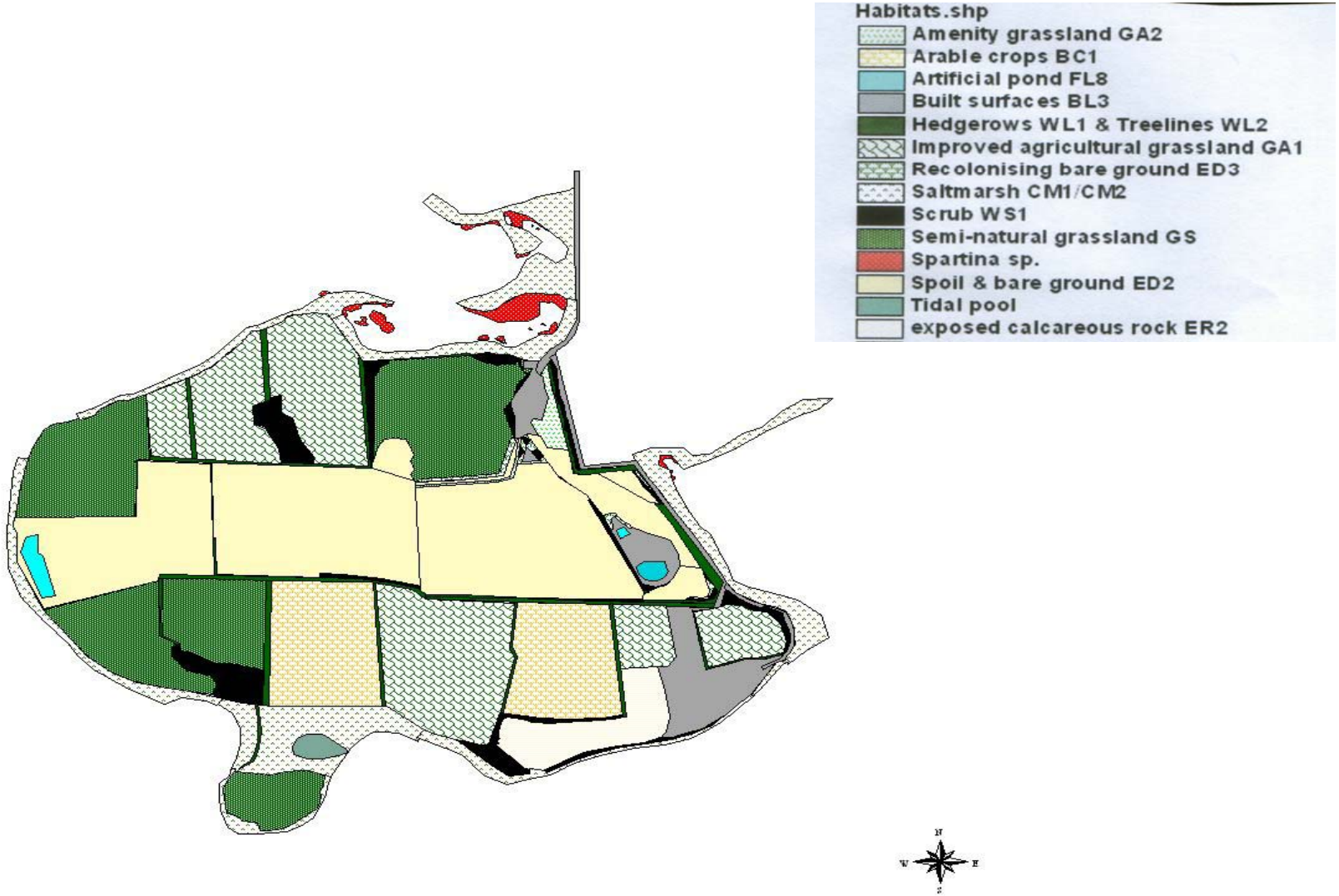
The southern boundary of the landfill site remained largely unchanged in 2008 and supports **hedgerow (WL1)** and **treeline (WL2)** habitats which separate the landfill site from agricultural habitats to the south. Species include Crab Apple, Hawthorn and Sycamore with associated scrub habitat dominated by Bramble and Nettle. As mentioned in Limosa Environmental (2007), a stand of the alien, invasive species Japanese Knotweed occurs along the southern boundary. This is an aggressively invasive species and signs of its spread are evident within the ED2 habitat nearby (sloping southern bank of landfill cap), where 17 new shoots of the plant were counted.

Young shoots of Japanese Knotweed (GPS grid reference for this area is 82553, 70226).

In June 2008, recent mechanical work within the site was also evident in the western extent of the site close to the artificial pond (FL8), where the dominant habitat was ED2 with small patches of ED3.

As in recent years, the plant Bristly Oxtongue was recorded in this area. This is a rare but introduced plant species in Ireland.

The northern most capped area is mapped as GS (semi-natural grassland) as it supports a well-established grassland community that does not easily fit into habitat categories. As a sown habitat it mostly resembles unimproved agricultural grassland and had recently been mown at the time of survey. On the sloping edge of this habitat in the east, and between it and the built area, is a large stand of Japanese Knotweed.


Habitats.shp
Amenity grassland GA2
Arable crops BC1
Artificial pond FL8
Built surfaces BL3
Hedgerows WL1 & Treelines WL2
Improved agricultural grassland GA1
Recolonising bare ground ED3
Saltmarsh CM1/CM2
Scrub WS1
Semi-natural grassland GS
Spartina sp.
Spoil & bare ground ED2
Tidal pool
exposed calcareous rock ER2

Habitats outside the landfill boundaries

Habitats in the surrounding environment are split into terrestrial habitats that occur immediately beyond the site boundaries and coastal habitats that occur around the coastline of Rossmore peninsula including saltmarsh that occurs at the transition between land and sea:

Terrestrial Habitats	Coastal Habitats
Improved Agricultural Grassland (GA1)	Lower Saltmarsh (CM1)
Semi-natural grassland (GS)	Upper Saltmarsh (CM2)
Hedgerows (WL1)	Mixed Substrata Shore (LR4)
Treelines (WL2)	Shingle and gravel banks (CB1)
Scrub (WS1)	
Exposed calcareous rock (ER2)	
Arable crops (BC1)	
Built surfaces (BL3)	

The dominant habitats in the immediate vicinity of the landfill site are agricultural which entirely cover the remaining terrestrial element of Rossmore Peninsula. These habitats are classified depending upon their land-use type (i.e. grassland or arable) and, in the case of grassland, upon the level of management.

While some **arable (BC1)** fields occur to the south of the landfill site, grassland fields are classified as either **improved agricultural grassland (GA1)** or **semi-natural grassland (GS)**, a broader classification used for areas of unmanaged grassland found to the north, south and west of the landfill site.

Agricultural fields are mostly bordered by **hedgerows (WL1)** with occasional **treelines (WL2). Scrub (WS1)** often occurs in association with the hedgerows and bramble and gorse scrub often dominates the boundary between the agricultural habitats and the shoreline.

Buildings and artificial surfaces (BL3) occurs on the south-eastern corner of Rossmore peninsula and comprise domestic dwellings, farm buildings, a shellfish plant and domestic gardens. A man-made pond (not mapped) also occurs here.

Also in the south-east is an area of bare, exposed rock, bordered by scrub (predominantly gorse). The habitat is classified as **exposed calcareous rock (ER2)** and supports a diversity of plants that favour limestone/calcareous habitats including Yellow-wort, a species that favours limestone habitats and has a localised distribution within Ireland (Preston *et al.,* 2002).

ER2 habitat merges into **upper saltmarsh (CM2)** below.

Saltmarsh habitat covers the transition from terrestrial to intertidal (littoral) habitats and occurs as **lower saltmarsh (CM1) and upper saltmarsh (CM2).** Because of their position, saltmarshes are subject to periodic immersion by the tides; lower saltmarsh located lower on the shore necessarily being subject to a greater degree of immersion than upper saltmarsh.

Saltmarsh habitat is present to varying degrees around Rossmore Peninsula. The largest expanses and best developed areas occur in the inner parts of Rossmore Bay and in the inner sections of Brick Island Embayment (Figure 2). Lower saltmarsh in Rossmore Bay is dominated by Common Cord-grass with Glasswort and Lax-flowered Sea-lavender. Lower saltmarsh within Brick Island Embayment is dominated by Sea Purslane with occasional strands of *Spartina* sp.

Lower and upper saltmarsh also occurs in varying degrees around the shoreline of Rossmore Peninsula. Often only small patches of Glasswort are seen, in other places there are quite dense stands of Lax-flowered Sea-lavender. Zonation from lower to upper shore was often observed to be:
Glasswort sp. > Lax-flowered Sea-lavender > Sea Beet/Common Saltmarsh-grass > Thrift.

A 'new' saltmarsh plant record in 2008 was Sea Pearlwort recorded along the southern shore of Rossmore Peninsula.

Sea Purslane

Lax-flowered Sea-lavender

Where saltmarsh is lacking, the upper shoreline exhibits a stone/gravel community that corresponds to **shingle and gravel banks (CB1).** Below the strandline the shingle and gravel community gives way to a **mixed substrata shore** (LR4) which is described further in Section 3.

Saltmarsh also occurs as an extensive habitat around a tidal pool on the southern most section of Rossmore Peninsula (Figure 2). The pool is connected to the sea via an inlet and its surrounding vegetation is dominated by Glasswort sp, Annual Sea-blite, Common Orache and Sea Beet.

2.3 Discussion and Conclusions

2.3.1 General Discussion

Habitats outside of the landfill site continue to support a diversity of flora and fauna and no obvious differences in the extent or quality of these habitats was noted in 2008 compared with recent previous annual surveys.

Coastal and intertidal habitats that surround Rossmore Peninsula are considered of high ecological value. The intertidal and saltmarsh habitats are within an area designated as the Great Island Channel candidate Special Area of Protection (SAC Site Code 1058) (See Section 2.1.1). Habitats listed on Annex I of the EU Habitats Directive include Atlantic salt meadows (code 1130) (equivalent to Fossitt CM1/CM2) and mudflats and sandflats not covered by seawater at low tide (Code 1140). These habitats are considered of international importance.

The majority of habitats inside the landfill boundaries are artificial or modified in nature and are subject to on-going disturbance as a result of the rehabilitation process now underway since the landfill's closure in 2007.

Small patches of semi-natural habitats occur in association with the site such as hedgerows, treelines and scrub, many of these along site boundaries. These habitats have changed relatively little over time and provide nesting and feeding areas for birds, insects and mammals as well as being wildlife corridors facilitating wildlife movement across Rossmore Peninsula.

The majority of the landfill cap was classified as spoil and bare ground during the survey period. It is likely that this area will be planted with vegetation (e.g. grass species) as part of site rehabilitation. Ideally

rehabilitation of the landfill site should include a habitat creation plan that considers not only the habitat within the landfill site, but also the ecological sensitivities of habitats surrounding the landfill site. For instance, accidental introduction of alien, invasive species or highly competitive native species that have the potential to spread into surrounding habitats, could affect the integrity of those habitats considered of high ecological value. Continued ecological monitoring during the site rehabilitation process is therefore recommended to assess these factors.

Japanese Knotweed was first noted within the landfill site in 2004 (ASU 2004) and was recorded at two locations during 2006 and 2007. As noted in Limosa Environmental (2007), this species is an alien, invasive species; being aggressively competitive and able to out-compete native flora where it takes hold. It spreads with enormous vigour via underground rhizome systems and can re-generate from tiny pieces of stem fragment; therefore simple cutting back can act as to spread the plant further. The County Cork Local Biodiversity Action Plan (Cork County Council, 2008) highlights Japanese Knotweed as one of the known threats to biodiversity.

At East Cork landfill site, the potential spread of Japanese Knotweed into the surrounding coastal habitats of high conservation importance is therefore of concern. We recommend that control measures are put in place at this early stage and advice should be sought with regards the correct measures of removal. Management guidelines can be found at http://www.invasivespeciesireland.com.

2.3.2 Ten -year comparison

2008 marks ten years since an ecological survey was carried out for the East Cork Landfill waste licence application in 1998 (Biosphere Environmental Services, 1998). This section of the current report therefore aims to compare and contrast results between these two surveys.

Despite differences in habitat classification between the two survey periods, habitat types can be assessed based on their descriptions and species profiles.

The major habitat type within the landfill site in 1998 was described as ‘disturbed weedy ground’ applicable to spoil and bare ground (ED2) and recolonising bare ground (ED3), the dominant habitat types in 2008. The capped area in the northern extent of the site has also appeared to have changed little in a ten-year period, being classified as improved grassland in 1998 and GS (semi-natural; grassland) in 2008, the latter classification referring to a greater diversity of grass and herb species having developed over the years.

Similarly, habitats outside the landfill boundary appear to have changed little in a ten-year period. Biosphere Environmental Services (1998) refer to agricultural fields to the north, south and west of the site with habitats varying from improved agricultural grassland, rough grassland (applicable to semi-natural grassland) and arable fields; the same as in 2008.

In 1998, the major areas of saltmarsh were in inner Rossmore Bay and ‘to the east of the site’ (Brick island Embayment), the same as in 2008. The habitat map of 1998 (Biosphere Environmental Services, 1998) also shows the band of saltmarsh habitat around the shoreline of Rossmore Peninsula that occurs in 2008.

Other comparisons/contrasts include:

- A total 75 vascular plant species were recorded in 1998 compared to 104 in 2008. This may be due to a smaller survey area being surveyed in detail in 1998.
- All species of saltmarsh plant recorded in 1998 are still present in 2008.
- (Biosphere Environmental Services, 1998) recorded a scarce plant henbane (*Hyoscyamus niger*) in 1998. An ephemeral plant of bare and disturbed ground, this species is not currently known within County Cork (T. O’Mahony (BSBI County Recorder) *pers. comm*.).
- The invasive, alien species Japanese Knotweed was not recorded in 1998.

Other features of interest within the past ten years include:

- Bristly oxtongue, a scarce but introduced species in Ireland, was first recorded within the landfill site in 2006 and was noted as being more abundant in 2007. Despite the works within the landfill site during 2008, a small population of this plant still remains.

- Yellow-wort was recorded for the first time in 2006 and again in 2007 and 2008. It occurs within the area of exposed calcareous rock (ER2) on the south of the peninsula. It is a plant of dry calcareous grassland and has a localised distribution within Ireland, being centred within the mid-west and south-east of the country and being rare in the south-west (Preston *et al.,* 2002).

- Common Cord-grass (*Spartina* sp.) distribution appears to have changed little since the 2006 survey apart from some of the smaller patches appearing to have increased in size slightly.

  Common Cord-grass has been recorded within the study area for many years as a lower saltmarsh species and is particularly prevalent within inner Rossmore Bay. This plant is an alien invasive species and first appeared in Ireland in the 1920's. There has been much debate as to potential impacts of *Spartina* sp. on the ecology of the habitat it invades and some negative effects have been proposed such as alteration of saltmarsh plant diversity, habitat loss for shorebirds and negative effects upon benthic invertebrates (e.g. Millard & Evans, 1984; Nairn, 1986). However, some recent studies suggest that negative impacts may not be as serious as previously predicted (McCorry *et al.,* 2003) and the spread of the species and subsequent effects appear to vary on a site by site basis.

  At Rossmore, Common Cord-grass does not appear to have undergone a major invasion of the mudflat habitat and appears to have remained relatively similar, in terms of area covered, at least for the past three, years. Comparison over a longer time period is difficult as previous surveys have not always mapped or quantified its distribution. A more accurate assessment of *Spartina* distribution over time could be undertaken using historical aerial photographs for the site.

2.4 Notes on terrestrial fauna associated with the landfill site and environs

Terrestrial fauna were recorded during the site habitat survey together with records collected during other monitoring. Dr P. Sleeman visited the site in summer 2008 to re-assess previously identified mammal records (e.g. otter locations).

MAMMALS

Mammal Species within the landfill boundaries

The only mammal signs noted within the landfill site were those of Rabbits (*Oryctolagus cuniculus*). Signs were in the form of droppings (across the site), various burrows, particularly in boundary banks and hedgerows and direct observations. No other mammal signs were observed within the landfill boundary, not surprising given the level of vehicular movement and disturbance to earth occurring as a consequence of the landfill rehabilitation programme.

Mammal Species within the surrounding environment

Outside the landfill boundaries, signs of rabbits were common throughout the survey area, and noted all along the peninsula shoreline. Unmanaged agricultural land adjacent to the landfill site (just north-east) has an extensive rabbit population plus numerous evidence of their predators (e.g. Fox *Vulpes vulpes*). An old, deserted badger (*Meles meles*) sett also occurs in this area; apparently still inactive in 2008.

The otter (*Lutra lutra*) seat found during the 2006 survey has largely been eroded away in 2008 and it is evident that coastal erosion will be a problem on the southern peninsula in years to come.

An otter spraint was recorded on a rock nearby to the 'seat' location which suggests that this mammal species is still regularly using the study area.

Otters are a protected species under the Wildlife Act of 1976 as amended in 2000, the European Communities (Natural Habitats) Regulations of 1997, Annex II of the Habitats Directive 1992 and Appendix II of the Bern Convention. Otters are known to have declined in Ireland by 17.72% between 1981 and 2005 (as measured by the percentage of positive sprainting sites reported) (Bailey & Rochford, 2006).

TERRESTRIAL BIRDS

Bird Species within the landfill boundaries

17 bird species were recorded within the landfill site during the 2008 surveys (Appendix 2.3). The majority of these birds were recorded within hedgerow and/or scrub habitats that occur along the site boundaries, the southern boundary being of prime importance.

The area of semi-natural grassland (GS) close to the built area in the north of the site (oldest capped area) provides a feeding ground for species such as Starling (*Sturnus vulgaris*) and Linnet (*Carduelis cannabina*). Sand Martin (*Riparia riparia*) and Swallow (*Hirundo rustica*) were also observed foraging aerially over this habitat. Meadow Pipits (*Anthus pratensis*) were recorded breeding within this habitat in 2007 but not during the current survey; possibly because the area had recently been mown. In future years it is recommended that mowing be delayed until later in the season to avoid destruction of nests of these ground-nesting birds.

Bird Species within the surrounding environment

31 bird species were recorded in the habitats surrounding East Cork landfill site during the 2008 surveys (Appendix 2.3). This result is significantly greater than the species list compiled in 2004 (ASU, 2004) (12 terrestrial bird species) and greater than the list compiled in 1998 (23 terrestrial bird species) (Biosphere Environmental Services, 1998). This suggests that bird diversity of Rossmore Peninsula has, at minimum, remained stable over the 10-year period 1998-2008.

Of note is the significant reduction in corvid species (rooks, crows) since the landfill closure in 2007.

BUTTERFLIES

The following butterfly species were recorded during fieldwork in June 2008:-

- Common Blue (*Polyommatus icarus*) - this species was recorded in abundance in association with the flowering plant Bird's-foot Trefoil (ED3 habitat) inside the landfill boundaries. Bird's-foot Trefoil is this species' food plant. This butterfly is considered widespread and common (DNFC, 2004).
- Small Blue (*Cupido minimus)* – this species was also recorded on the flowering plant Bird's-foot Trefoil (ED3 habitat), inside the landfill boundaries. This is Ireland's smallest butterfly and is quite scarce and local in its distribution. It is found on coastal sand dunes and calcareous ground inland and its only larval food plant Kidney Vetch (*Anthyllis vulneraria*) (DNFC, 2004) which is related to Bird's-foot Trefoil.
- Meadow Brown (*Maniola jurtina*) - widespread and common in meadows and grassy places.
- Large White (*Pieris brassicae*) – observed inside the landfill site within recolonising bare ground habitat.

Appendix 2.1

SITE SYNOPSIS: GREAT ISLAND CHANNEL SAC & NHA (SITE CODE 01058)

The Great Island Channel stretches from Little Island to Midleton, with its southern boundary being formed by Great Island. It is an integral part of Cork Harbour which contains several other sites of conservation interest. Geologically, Cork Harbour consists of two large areas of open water in a limestone basin, separated from each other and the open sea by ridges of Old Red Sandstone. Within this system, Great Island Channel forms the eastern stretch of the river basin and, compared to the rest of Cork Harbour, is relatively undisturbed. Within the site is the estuary of the Owennacurra and Dungourney Rivers. These rivers, which flow through Midleton, provide the main source of freshwater to the North Channel.

The main habitats of conservation interest are the sheltered tidal sand and mudflats and Atlantic salt meadows, both habitats listed on Annex I of the EU Habitats Directive. Owing to the sheltered conditions, the intertidal flats are composed mainly of soft muds. These muds support a range of macro-invertebrates, notably *Macoma balthica*, *Scrobicularia plana*, *Hydrobia ulvae*, *Nepthys hombergi, Nereis diversicolor* and *Corophium volutator*. Green algal species occur on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially at Rossleague and Belvelly. The salt marshes are scattered through the site and are all of the estuarine type on mud substrate. Species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Greater Sea-spurry (*Spergularia media*), Sea Lavender (*Limonium humile*), Sea Arrowgrass (*Triglochin maritimum*), Mayweed (*Matricaria maritima*) and Red Fescue (*Festuca rubra*).

The site is extremely important for wintering waterfowl and is considered to contain three of the top five areas within Cork Harbour, namely North Channel, Harper's Island and Belvelly-Marino Point. Shelduck are the most frequent duck species with 800-1000 birds centred on the Fota/Marino Point area. There are also large flocks of Teal and Wigeon, especially at the eastern end. Waders occur in the greatest density north of Rosslare, with Dunlin, Godwit, Curlew and Golden Plover the commonest species. A population of about 80 Grey Plover is a notable feature of the area. All the mudflats support feeding birds; the main roost sites are at Weir Island and Brown Island and to the north of Fota at Killacloyne and Harper's Island. Ahanesk supports a roost also but is subject to disturbance. The numbers of Grey Plover and Shelduck, as given above, are of national importance.

The site is an integral part of Cork Harbour which is a wetland of international importance for the birds it supports. Overall, Cork Harbour regularly holds over 20,000 waterfowl and contains internationally important numbers of Black-Tailed Godwit (1,181) and Redshank (1,896) along with nationally important numbers of nineteen other species. Furthermore, it contains the large Dunlin (12,019) and Lapwing (12,528) flocks. All counts are average peaks, 1994/95 – 1996/97. Much of the site forms part of Cork Harbour Special Protection Area, an important bird area designated under the EU Birds Directive.

While the main land use within the site is aquaculture (Oyster farming), the greatest threats to its conservation significance come from road works, infilling, sewage outflows and possible marina developments.

The site is of major importance for the two habitats listed on the EU Habitats Directive that it contains, as well as for its important numbers of wintering waders and wildfowl. It also supports a good invertebrate fauna.

2.10.2001

SITE SYNOPSIS: CORK HARBOUR SPA (SITE CODE 4030)

Cork Harbour is a large, sheltered bay system, with several river estuaries – principally those of the Rivers Lee, Douglas, Owenboy and Owenacurra. The SPA site comprises the main intertidal areas of Cork Harbour, including all of the North Channel, the Douglas Estuary, inner Lough Mahon, Monkstown Creek, Lough Beg, the Owenboy Estuary, Whitegate Bay and the Rostellan inlet.

Owing to the sheltered conditions, the intertidal flats are often muddy in character. These muds support a range of macro-invertebrates, notably *Macoma balthica*, *Scrobicularia plana*, *Hydrobia ulvae*, *Nepthys hombergi, Nereis diversicolor* and *Corophium volutator*. Green algae species occur on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially where good shelter exists, such as at Rossleague and Belvelly in the North Channel. Salt marshes are scattered through the site and these provide high tide roosts for the birds. Salt marsh species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Lax-flowered Sea-lavender (*Limonium humile*) and Sea Arrowgrass (*Triglochin maritima*). Some shallow bay water is included in the

site. Cork Harbour is adjacent to a major urban centre and a major industrial centre. Rostellan Lake is a small brackish lake that is used by swans throughout the winter. The site also includes some marginal wet grassland areas used by feeding and roosting birds.

Cork Harbour is an internationally important wetland site, regularly supporting in excess of 20,000 wintering waterfowl, for which it is amongst the top five sites in the country. The five-year average annual core count for the entire harbour complex was 34,661 for the period 1996/97-2000/01. Of particular note is that the site supports an internationally important population of Redshank (1,614) – all figures given are average winter means for the 5 winters 1995/96-1999/00. A further 15 species have populations of national importance, as follows: Great Crested Grebe (218), Cormorant (620), Shelduck (1,426), Wigeon (1,750), Gadwall (15), Teal (807), Pintail (84), Shoveler (135), Red-Breasted Merganser (90), Oystercatcher (791), Lapwing (3,614), Dunlin (4,936), Black-Tailed Godwit (412), Curlew (1,345) and Greenshank (36). The Shelduck population is the largest in the country (9.6% of national total), while those of Shoveler (4.5% of total) and Pintail (4.2% of total) are also very substantial. The site has regionally or locally important populations of a range of other species, including Whooper Swan (10), Pochard (145), Golden Plover (805), Grey Plover (66) and Turnstone (99). Other species using the site include Bat-tailed Godwit (45), Mallard (456), Tufted Duck (97), Goldeneye (15), Coot (77), Mute Swan (39), Ringed Plover (51), Knot (31), Little Grebe (68) and Grey Heron (47). Cork Harbour is an important site for gulls in winter and autumn, especially Common Gull (2,630) and Lesser Black-Backed Gull (261); Black-Headed Gull (948) also occurs.

A range of passage waders occur regularly in autumn, including Ruff (5-10), Spotted Redshank (1-5) and Green Sandpiper (1-5). Numbers vary between years and usually a few of each of these species over-winter.

The wintering birds in Cork Harbour have been monitored since the 1970s and are counted annually as part of the I-WeBS scheme.

Cork Harbour has a nationally important breeding colony of Common Tern (3-year mean of 69 pairs for the period 1998-2000, with a maximum of 102 pairs in 1995). The birds have nested in Cork Harbour since about 1970, and since 1983 on various artificial structures, notably derelict steel barges and the roof of a Martello Tower. The birds are monitored annually and the chicks are ringed.

Extensive areas of estuarine habitat have been reclaimed since about the 1950s for industrial, port-related and road projects, and further reclamation remains a threat. As Cork Harbour is adjacent to a major urban centre and a major industrial centre, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. However, the polluted conditions may not be having significant impacts on the bird populations. Oil pollution from shipping in Cork Harbour is a general threat. Recreational activities are high in some areas of the harbour, including jet skiing which causes disturbance to roosting birds.

Cork Harbour has is of major ornithological significance, being of international importance both for the total numbers of wintering birds (i.e. > 20,000) and also for its population of Redshank. In addition, there are at least 15 wintering species that have populations of national importance, as well as a nationally important breeding colony of Common Tern. Several of the species which occur regularly are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-Tailed Godwit, Ruff and Common Tern. The site provides both feeding and roosting sites for the various bird species that use it.

Appendix 2.2

Latin and common names of plants are given for all species recorded within or adjacent to the landfill site. Species names and nomenclature follow Stace (1997) (*i.e*. that used in *Flora Atlas* (Preston *et al*. 2000), and frequency of occurrence in Ireland follows Webb *et al*. (1996).

Habitats: FL8 (artificial pond); GA1 (improved agricultural grassland); GA2 (amenity grassland); GS (semi-natural grassland); GS2 (dry meadows and grassy verges); WL1 (hedgerows); WL2 (treelines); WS1 (scrub); ER2 (exposed calcareous rock); ED2 (spoil & bare ground); ED3 (recolonising bare ground); BC1 (arable crops); CM1 (lower saltmarsh); CM2 (Upper saltmarsh).

Latin Name	Common Name	Frequency of occurrence in Ireland	Habitat where recorded
Acer pseudoplatanus	Sycamore	Abundant	WL1, WL2
Achillea millefolium	Yarrow	Abundant	GA2, CM2
Agrostis stolonifera	Creeping Bent	Abundant	GA2, CM2,
Anagallis arvensis	Scarlet Pimpernel	Occasional to frequent	ED3, ED2,
Anthyllis vulneraria	Kidney Vetch	Frequent near coast	CM2
Armeria maritima	Thrift	Frequent	CM2, CM1
Arrhenatherum elatius	False Oat-grass	Abundant	GA2, WS1, GS2, GS,
Aster tripolium	Sea Aster	Very frequent	CM2
Atriplex portulacoides	Sea Purslane	Locally abundant E & S, rare W & N	CM1
Atriplex patula	Common Orache	Frequent	CM2
Bellis perennis	Daisy	Abundant	GA2
Beta vulgaris subsp. *maritima*	Sea Beet	Widespread but occasional	CM1, CM2
Blackstonia perfoliata	Yellow-wort	locally frequent in centre, rare in south-west.	ER2
Brassica napus	Rape	Occasional	ED3
Buddleja davidii	Butterfly-bush	Frequent in Cork, non-native	WL1, WL1, WS, ER2
C*alystegia sepium*	Hedge Bindweed	Frequent	ED3, WL1,
Calystegia soldanella	Sea Bindweed	Rare in S & E	CM2
Capsella bursa-pastoris	Shepherd's-purse	Abundant	ED3
Carex species	Sedge species	-	CM2
Centaura nigra	Common Knapweed	Abundant	ED3
Centaurium erythraea	Common Centaury	Very frequent near the sea	ER2, CM2
Cerastium fontanum	Common Mouse-ear	Abundant	ED3
Cirsium vulgare	Spear Thistle	Abundant	WL1,
Chamaerion angustifolium	Rosebay Willowherb	Locally frequent	ED3, WL1
Chenopodium album agg.	Fat-hen	Frequent	ED3, ER2
Cirsium arvense	Creeping Thistle	Abundant	ED3
Cirsium vulgare	Spear Thistle	Abundant	ED3, WL1
Cochleria officinale	Common Scurvey-grass	Frequent	CM2
Crataegus monogyna	Hawthorn	Locally frequent	WL1, WL2
Dactylis glomerata	Cock's-foot	Abundant	GS2, GS
Digitalis purpurea	Foxglove	Very frequent	ED3
Elytrigia repens	Common Couch	Abundant	GS2, GS
Epilobium hirsutum	Great Willowherb	Very frequent	WL1
Euphorbia helioscopa	Sun Spurge	Very frequent	ED3
Fallopia japonica	Japanese Knotweed	Frequent, increasing	ED3, WL1,
Festuca rubra	Red Fescue	Abundant	CM2
Fraxinus excelsior	Ash	Frequent	WL1, WL2
Fumaria officinalis	Common Fumitory	Frequent near the east coast, rarer elsewhere	ED3
Geranium robertianum	Herb Robert	Abundant	ED3
Geum urbanum	Wood Avens	Frequent	WL
Hedera helix	Ivy	Widespread and abundant	WL
Heracleum sphondylium	Hogweed	Abundant	WS1, WL1
Hieracium sp.	Hawkweed sp.	Frequent	ED3
Holcus lanatus	Yorkshire Fog	Abundant	GA2, ED3, GS
Lactuca serriola	Prickly Lettuce	-	ED3, CM2

Lathyrus pratensis	Meadow Vetchling	Abundant	CM2, GS
Leontodon autumnalis	Autumn Hawkbit	Frequent	ED3, GA2
Limonium humile	Lax-flowered Sea-lavender	Abundant	CM1, CM2
Lolium perenne	Perennial Rye-grass	Abundant	GS
Lonicera periclymenum	Honeysuckle	Frequent and widespread	WL1
Lotus corniculatus	Bird's-foot Trefoil	Abundant	ED3, WL1, CM2
Malus sylvestris	Crab Apple	-	WL2
Malva sylvestris	Common Mallow	Frequent in south	ED3
Matricaria discoidea	Pineappleweed	abundant	ED3
Petasites hybridus	Butterbur	Frequent but local	WS1, ED3, ED2
Picris echioides	Bristly Oxtongue	Very rare 9introduced)	ED3
Plantago coronopus	Buck's-horn Plantain	Very frequent	CM2
Plantago lanceolata	Ribwort Plantain	Abundant	GA2, ED3, GS
Plantago major	Greater Plantain	Abundant	ED2
Plantago maritima	Sea Plantain	Very frequent	CM2, CM1
Poa annua	Annual Meadow-grass	Abundant	ED3, CM2
Polygonum aviculare agg	Knotgrass	Abundant	ED2, ED3,
Poplus sp.	Popular sp.	-	WL2
Potentilla anserina	Silverweed	Abundant	ED3
Potentilla erecta	Tormentil	Abundant	GS2, ED2, ED3,
Potentilla reptans	Creeping Cinquefoil	Frequent in south and centre, rarer in north	CM2
Prunella vulgaris	Self Heal	Abundant	CM2
Pteridium aquilinum	Bracken	abundant	WL1
Puccinella maritima	Common Saltmarsh-grass	Very frequent	CM1, CM2
Ranunculus repens	Creeping Buttercup	Abundant	GA2, ED3,
Reseda luteola	Weld	Frequent	
Rosa canina	Dog Rose	Very frequent	WL1
Rubus fruticosus agg.	Bramble	Abundant	WS1, ED3,
Rumex acetosa	Common Sorrel	Abundant	ED3, GS2,
Rumex crispus	Curled Dock	Abundant	
Rumex obtusifolius	Broad-leaved Dock	Abundant	WS1, ED3,
Sagina maritima	Sea Pearlwort	Occasional	CM2
Sambucus nigra	Elder	Frequent	WL1, WL2
Salicornia species	Glasswort species	Frequent	CM1
Salix sp.	Willow	Frequent	WL1, WL2
Scrophularia auriculata	Water Figwort	Frequent in S & W	
Scrophularia nodosa	Common Figwort	Very frequent	ED3,
Senecio jacobaea	Common Ragwort	Abundant	GA2, GS2, WS1, ED3, WL1, ER2
Senecio vulgaris	Groundsel	Very frequent	ED3,
Silene uniflora	Sea Campion	Very frequent	ED3, CM2
Silene latifolia	White Campion	Locally frequent in centre and south-east, rare elsewhere	ED3
Sinapis arvensis	Charlock	Frequent	ED3
Sonchus oleraceus	Smooth Sow-thistle	Frequent	GS2
Sonchus asper	Prickly Sow-thistle	Very frequent	ED3
Spartina anglica	Common Cord-grass	Locally abundant	CM1
Spergularia marina	Lesser Sea-spurrey	Very frequent	CM1, CM2
Stachys sylvatica	Hedge Woundwort	Very frequent	ED3
Stellaria media	Common Chickweed	Abundant	ED2
Suaeda maritima	Annual Sea-blite	Frequent	CM1
Taraxacum officinale	Dandelion	Abundant	GA2
Trifolium pratense	Red Clover	Abundant	WL1
Trifolium repens	White Clover	Abundant	CM2
Triglochin maritimum	Sea Arrowgrass	Very frequent	CM2, CM1
Tripleurospermum inodorum	Scentless Mayweed	Disturbed ground, occasional	ED3
Tripleurospermum maritimum	Sea Mayweed	Very frequent	CM2
Ulex europaeus	Gorse	Abundant	WS1, WL1, ER2
Urtica dioica	Common Nettle	Abundant	ED3, WS1, WL1,
Veronica persica	Common Field-speedwell	Abundant	ED3
Vicia cracca	Tufted Vetch	Abundant	WL1

Appendix 2.3

Terrestrial bird species recorded inside East Cork Landfill and within the surrounding environment.

Birds of conservation concern are listed as per Lynas et al. (2007):- Criteria: SPEC = European conservation status.

Bird Species	Observed inside landfill boundaries	Observed outside landfill boundaries	Listed on Birds Of Conservation Concern (Lynas *et al.,* 2007))
Blackbird *Turdus merula*	*	*	
Blue Tit *Parus caeruleus*	*	*	
Bullfinch *Pyrrhula pyrrhula*		*	
Chaffinch *Fringilla coelebs*	*	*	
Chiffchaff *Phylloscopus collybita*		*	
Coal Tit *Parus ater*		*	
Dunnock *Prunella modularis*	*	*	
Goldcrest *Regulus regulus*		*	
Goldfinch *Carduelis carduelis*		*	
Great Tit *Parus major*	*	*	
Greenfinch *Carduelis chloris*	*	*	
Hooded Crow *Corvus corone cornix*		*	
Jackdaw *Corvus monedula*		*	
Kestrel *Falco tinnunculus*		*	Amber-list (SPEC)
Linnet *Carduelis cannabina*	*	*	Amber-list (SPEC)
Long-tailed Tit *Aegithalos caudatus*		*	
Magpie *Pica pica*	*	*	
Meadow Pipit *Anthus pratensis*	*	*	
Pheasant *Phasianus colchicus*		*	
Pied Wagtail *Motacilla alba*		*	
Raven *Corvus corax*		*	
Robin *Erithacus rubecula*	*	*	
Rook *Corvus frugilegus*	*	*	
Sand Martin *Riparia riparia*	*	*	Amber-list (SPEC)
Song Thrush *Turdus philomelos*	*	*	
Snipe *Gallinago gallinago*		*	Amber-list (SPEC)
Starling *Sturnus vulgaris*	*	*	Amber-list (SPEC)
Stonechat *Saxicola torquata*		*	
Swallow *Hirundo rustica*	*	*	Amber-list (SPEC)
Willow Warbler *Phylloscopus trochilus*		*	
Wood Pigeon *Columba palumbus*	*	*	
Wren *Troglodytes troglodytes*	*	*	

3.0 INTERTIDAL SURVEY OF ROSSMORE BAY AND PENINSULA

3.1 Introduction

The annual landfill monitoring programme has ensured that the same intertidal sites are sampled every year and the results are therefore comparable across the years. The survey includes the following components:

- An assessment of the fauna and flora of the hard shore and intertidal mudflats of Rossmore Bay, Rossmore Peninsula (North Channel) and the Brick Island Embayment (core sampling and quadrat survey).
- Sediment chemical analysis.
- Sediment particle size analysis (granulometry).

3.2 Methodology

The intertidal survey was undertaken on 12/09/2008 and 17/09/2008 at locations around Rossmore Peninsula, Rossmore Bay and Brick Island Embayment (Figure 3).

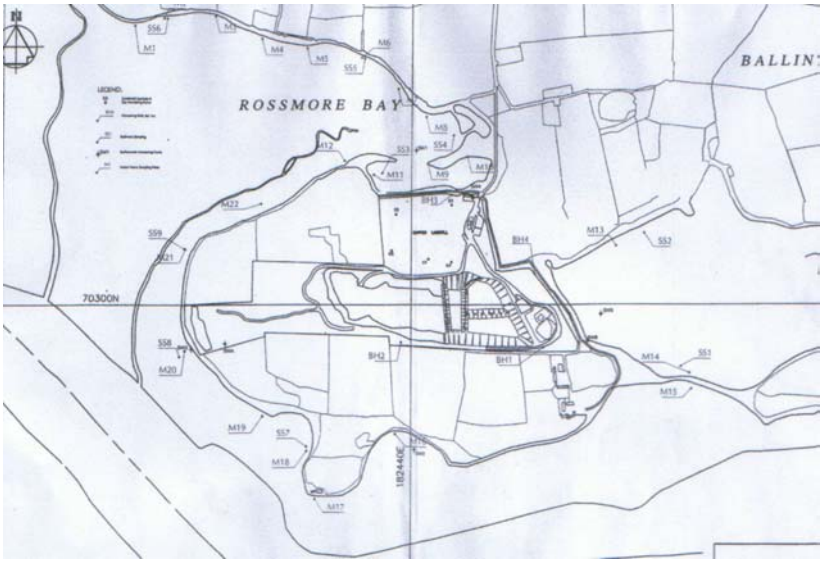


Figure 3 Rossmore Bay and position of intertidal sampling sites. Macrofaunal sampling sites are numbered M1 to M22; sediment sampling sites for chemical analysis are numbered SS1 to SS9 (figure reproduced from Cork County Council).

3.2.1 Core sampling

Core-samples were taken at 22 sites (Sites M1 – M22, Figure 3). The location of each sampling site was determined with a hand-held GPS and cross-referenced with the grid reference from previous annual surveys (Note - the grid reference was taken on the hard shore directly above the mudflat where the cores were taken).

Initially a qualitative assessment was made of each core sampling location. This included recording physical features such as: sediment type (i.e. mud, sandy mud, muddy sand or sand), presence and depth of the anoxic layer, proximity of the river channel and/or drainage channels/creeks, presence of standing water and visible signs of fauna on the sediment surface.

In line with methodology previously adopted, a single core sample was taken from each site. Core sampling followed standard methodology, each sample being taken with a 0.01m^2 cylindrical core to a depth of 15cm (Dalkin & Barnett, 2001). The samples were sieved within low-tide channels on site using a 0.5-mm mesh stainless steel sieve and placed into labelled, watertight plastic bags for transport.

Laboratory processing began with each sample being washed over a 0.5mm-mesh sieve with tap water to further clean the sample. Each sample was placed into a white plastic tray for sorting (visual screening of the tray). Macroinvertebrate species detected by eye were placed into labelled sample storage containers with 70% Ethanol.

Sample identification proceeded with the use of a dissecting microscope (Brunel BZM x10 – x20 zoom stereomicroscope). Identification keys (e.g. Hayward & Ryland, 1995) were consulted where necessary. All invertebrates were subsequently counted and their relative abundance determined.

3.2.2 Rocky shore/upper littoral survey

Sampling of the rocky or upper intertidal habitat was undertaken at the 22 sampling sites used for core sampling (Figure 3.1). Three replicate quadrats were positioned randomly within the mid-shore zone. Quadrats measured 0.5m x 0.5m (area 0.25m^2). Within each quadrat, algal cover was recorded as % cover. Fauna were either counted directly (in the case of larger individuals) or recorded as % cover (in the case of barnacles).

The % cover of flora within quadrats is presented as an average within the three quadrats. Similarly, the abundance of barnacles is also presented as average % cover. In the case of other fauna, the average abundance within three quadrats was determined, this then extrapolated to numbers/m^2 and the result presented as per the SACFOR Scale (following the Marine Nature Conservation Review SACFOR Abundance Scale, Connor *et al.,* 2004): S (Superabundant); A (Abundant); C (Common); F (Frequent); O (Occasional); R (Rare).

Marine biotope codes were assigned to sampling sites (both soft sediment and hard shore habitats) as per the Marine Biotope Classification of Britain and Ireland (Connor *et al.,* 2004). A biotope is defined as the 'physical habitat together with its characteristic community of plants and/or animals' (Connor *et al.,* 1997).

3.2.3 Sediment chemical and physical analysis

Sediment samples were taken at 9 No. sampling sites (Figure 3) on 16/10/08. A single control sample was also taken; sample 10 being a duplicate of sample 1. Sample site locations were the same as used in previous years; sample locations located using a hand-held GPS (Table 3.1).

Table 3.1 Location of sediment sampling sites as recorded with a hand-held GPS.

Sampling Site	Easting (m)	Northing (m)
1	182956	070157
2	182894	070479
3	182346	070568
4	182500	070650
5	182350	070799
6	181952	070879
7	182100	070000
8	182000	070225
9	181996	070458
10	182500	070650

At each site, small scoops of sediment (to a depth no greater than 10cm) were taken for organic carbon and granulometry analysis. A small sample of surface sediment was taken with a plastic scoop and packaged separately for metals analysis.

All samples were put into clean, sterile, plastic bags and labelled. Samples for chemical analysis were placed into a cool box for transport (via courier) to City Analysts, Limerick, Limited. Samples for granulometry analysis were placed into a container and delivered to Aquatic Services Unit (UCC) in Cork.

Laboratory analyses are described in Table 3.2.

Table 3.2 Sediment Chemical and Physical Analyses

Parameter	Method of Analysis	Units
Granulometry	Sieving	% Coarse Sand (2mm – 710µm) % Medium Sand (710 µm – 250 µm), % Fine Sand (250 µm - 63 µm), % Silt/Clay (< 63 µm)
Organic Carbon	Loss on Ignition (LOI)	%
Kjeldahl Nitrogen	Kjeldahl digestion and automated ammonia analysis	mg/g
Arsenic	Atomic adsorption spectrometry (AAS)	mg/kg
Cadmium	Atomic adsorption spectrometry (AAS)	mg/kg
Chromium	Atomic adsorption spectrometry (AAS)	mg/kg
Copper	Atomic adsorption spectrometry (AAS)	mg/kg
Lead	Atomic adsorption spectrometry (AAS)	mg/kg
Nickel	Atomic adsorption spectrometry (AAS)	mg/kg
Zinc	Atomic adsorption spectrometry (AAS)	mg/kg
Mercury	Atomic adsorption spectrometry (AAS)	mg/kg

3.3 Results & Discussion

3.3.1 Intertidal flora and fauna

Habitats

The 22 intertidal sampling locations range from the more exposed sites along Rossmore Peninsula to the relative shelter of sites within Brick Island Embayment or inner Rossmore Bay. Sites can therefore be clustered based on physical and biological conditions as shown in Table 3.3.

In general, the sites are characterised by an intertidal zone consisting of an upper shore of cobbles/pebbles which extends vertically towards a mudflat (with the exception of sites M10 and M11 which are backed by saltmarsh). In the majority of sites a zonation in particle size is observed from the upper to lower hard shore, the upper shore comprising larger cobbles and pebbles with occasional boulders which become progressively smaller down shore with pebbles and gravels dominating the zone just above the mudflat. In some cases there is no clear division between the hard (rock) littoral habitat and the soft (sediment) littoral habitat, as gravels and pebbles merge into the mudflat (e.g. M15). The 'hard shore' intertidal habitat is classified, according to Fossitt (2000) as a 'mixed substrata shore' (LR4).

The mudflat habitat varies from 'mud shore' (LS4) to 'muddy sand shore' (LS3) (See Section 3.3.4). Inner and more sheltered areas such as Rossmore Bay and Brick Island embayment are characterised by soft sediment (silt/clay) as a result of the low energy environment leading to deposition of fine silt/clay particles. These inner areas are also characterised by the presence of Common Cord Grass *Spartina* sp. (See Section 2). More exposed areas, such as the outer Rossmore Peninsula are characterised by coarser sandier particles.

Fauna and flora of the hard shore line

Flora and faunal species recorded during the quadrat survey are presented in Table 3.4.

A common feature of mixed substrata shorelines is the growth of fucoid algae (Fossitt, 2000) as seen at 19 out of the 22 sampling sites. The brown alga Egg Wrack (*Ascophyllum nodosum*) dominated with varying amounts of Bladder Wrack (*Fucus vesiculosis*).

Four sites exhibited the green alga *Enteromorpha* upon the hard shore, although its presence was due to being washed up with the tide. Algal mats of *Enteromorpha* however, did occur upon the mudflat habitat of several sites as reported later.

As found in previous years, the red alga *Polysiphonia lanosa* occurs as an epiphytic species (growing upon) Egg Wrack around Rossmore Peninsula.

Faunal species are restricted to barnacles *Semibalanus balanoides* and *Elminius modestus, the latter dominating,* Shore crabs (*Carcinus maenas*), Littorinid periwinkles, amphipod crustaceans (Talitridae (Sandhoppers) and Gammaridae). As found in 2007, Blue Mussels (*Mytilus edulis*) were only recorded at Site M3.

The dominant marine biotopes assigned to the mixed substrata shoreline (hard shore) are as follows:

- ***Ascophyllum nodosum* and *Fucus vesiculosis* on variable salinity mid eulittoral rock' (LR.LLR.FVS.AscVS**) – this biotope describes the dominant macroalgal species recorded but also the faunal community associated with it that includes winkles (*Littorina littorea, L. obtusata),* Barnacles (*Semibalanus balanoides and Elminius modestus*), occasional Mussels (*Mytilus edulis*) and Shore Crabs (*Carcinus maenas*).
- **Ephemeral green and red seaweeds on variable salinity and/or disturbed mixed substrata (LR.FLR.Eph.EphX)** –describes areas where green macroalgae (e.g. *Enteromorpha*) is present in a layer overlying pebbles and cobbles and/or mud/gravel.
- ***Fucus vesiculosis* on mid-eulittoral variable salinity boulders and stable mixed substrata (LR.LLR.Fves.VS)** – describes areas where a distinct zone of Bladder Wrack occurred.

Other observed biotopes include:

- **Saltmarsh (LS.LMp.S**m) – describes the saltmarsh community on the upper shore.
- **Strandline (LS.Lsa.St)** – a line of decomposing seaweed (wrack) left behind by a falling tide.
- **Shingle (pebble) and gravel shores (LS.LCS.Sh)** – a higher biotope code that could be used for areas with no further distinguishing characteristics/species.
- ***Pelvetia canaliculata* on sheltered, variable salinity littoral fringe rock (LR.LLR.FVS.PelVS) –** narrow band of Channel Wrack (*Pelvetia canaliculata*) found occasionally above the macroalgal zone.
- **Yellow and grey lichens on supralittoral rock (LR.FLR.Lic.YG)** – lichens growing on upper shore (supralittoral) rocks.
- ***Verrucaria maura* on littoral fringe rock (LR.FLR.LIV.Ver)** – characteristic black lichen growing on supralittoral rock.

Table 3.3 Overview of macrofauna sampling sites (M1-M22)

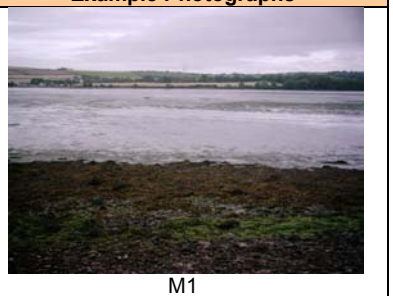
Sites	Hard Shore	Lower Mudflat	Example Photographs
M1 - M7 Northern shore of Rossmore Bay.	Sites are characterised by an upper zone of barren stones, a narrow (*c* 1m) zone of Channel Wrack (*Pelvetia caniculata*) followed by a narrow zone of Bladder Wrack (*Fucus vesiculosis*). The next zone down shore is dominated by Egg Wrack (*Ascophyllum nodosum*). Sometimes there is a zone of intermixed Egg Wrack and Bladder Wrack e.g. Site M4 where the latter dominated. An algal mat (*Enteromorpha* sp.) was present as the hard shore merges into the soft sediment but was rarely observed within hard shore quadrats.	Occasional algal mat present (*Enteromorpha* sp.). At M3 the mat extended out by c20m and was approx 5cm in depth. Epifauna included: *Hydrobia ulvae,* casts of Lugworm (*Arenicola marina*), visible signs of Ragworm (*Hediste diversicolor*), occasional Cockles (*Cerastoderma edule*).	 M1
M8 – M9 Inner Rossmore Bay	Upper zone of saltmarsh followed by a zone of washed up *Enteromorpha* that merges into *Egg Wrack zone.* Abundance of empty bivalve shells below M9.	Patchy algal mat present. Soft mud (silt/clay) sediment. Visible worm holes. Upper mudflat dominated by dense aggregations of juvenile Lugworms (*A. marina*)	
M10 – M11	No hard shore present, saltmarsh above M10; few cobbles only above M11, no flora or faunal zonation present.	Patchy algal mat present. Soft mud (silt/clay) sediment.	
M12 & M16 – M22	Wider shoreline, saltmarsh above, zone of cobbles and pebbles then a zone of Egg Wrack/Bladder Wrack. Egg wrack usually dominates. The red alga *Polysiphonia lanosa* often occurs as an epiphyte upon the Egg Wrack.	Sediment varies from soft silt/clay at M12 to muddy sand (silty sand) (e.g. M20, M22). Fauna observed included Lugworm casts, *H. ulvae*, feeding marks of the bivalve *Scrobicularia plana.*	 M22
M15 Brick Island	Upper shore boulders & cobbles with saltmarsh above; then a zone of patchy Egg Wrack followed by a zone of Bladder wrack. A mixed wrack zone on the lower shore just above the mudflat. Gravely shore - the gravel extending into the mudflat.	Sandy mud. Lugworm casts present, no algal mat.	
M13 & M14 Brick Island Embayment	At both sites, saltmarsh above, dominated by Sea Purslane and Lax-flowered Sea Lavender. M13 exhibits a *c*10m zone of barren cobbles followed by narrow zone of Egg Wrack before the Egg Wrack zone. M14 has a narrow zone of barren cobbles above the mudflat.	Soft silt/clay sediment. Some washed-up *Enteromorpha* sp. at M13.	

Table 3.4 Fauna of the hard shoreline of sampling sites M1 – M22.

Flora and Barnacles are presented as average % cover (average cover within 3 replicate quadrats). The red alga *Polysiphonia lanosa* is recorded as present/absent (X). Numbers of other faunal were averaged and then presented as per the SACFOR Scale (see Section 3.2.2). Sites M10 and M11 lack a hard shore and no visible epifauna was recorded.

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Flora																						
(average % cover)																						
Ascophyllum nodosum	90		100	2	100	9	96	48	97			81	66	26	16	100	25	50	70	46	96	66
Fucus vesiculosis		78		98		42						6	21		40		43	21		36	<1	30
Enteromorpha sp. (filamentous)								16					12	100				5				
Presence/Absence																						
Polysiphonia lanosa									X				X		X			X		X	X	X
Fauna																						
Barnacles (% cover)	12	5	10	20	5		2	<1								<1						
Other fauna (SACFOR Scale)																						
Mytilus edulis			R																			
Amphipods	F	C	C	C	F		F	O	O			O		O		O			O	F	F	F
Carcinus maenas			C				F		C							C				C	C	C
Littorina rudis	O	F		O												F			F			
Littorina littorea				O											F	F						
Littorina obtusata							F		C												F	F
Arenicola marina (Casts)															X							

Flora and fauna of the mudflats

The green macroalga *Enteromorpha* was recorded upon the mudflat at six sampling sites. In the majority of cases (M2, M8, M10, M19 & M22), the mat was thin and patchy. The exception was M2 (see photo below) where an extensive and thick mat (up to 8cm deep) was observed.

Algal mat at Site M2

Core-sample macroinvertebrates are shown in Table 3.5.

A total of 15 invertebrate taxa were found within the 22 sediment core samples. The major marine macroinvertebrate groups were represented (i.e. Worms, Molluscs and Crustaceans) although worms dominated in terms of diversity (Table 3.5).

Species richness, (a measure of the total number of species or taxa per sample) varied from one to seven across all sampling stations. As found in previous annual surveys, sites within Rossmore Bay recorded the highest species diversity, sites along the southern shore of Rossmore Peninsula (North Channel) recorded the lowest species diversity. Similarly, invertebrate abundance (number of individuals) was greatest within Rossmore Bay.

The mud snail *Hydrobia ulvae* dominated samples in terms of number (abundance) and frequency of occurrence, occurring at nine sites.

The second most frequent taxa were Spionidae worms – found within seven samples. These tiny and very fragile worms were identified to family level only as key identifying features such as the palps are easily lost during the sieving process. One species was identified to species level: *Scolelepis squamata.*

A new species to be recorded this year was the polychaete worm *Ampharete acutifrons* which was found at 6 sites and in numbers up to 13 per core which is classed as 'superabundant' on the MNCR SACFOR abundance scale.

Oligochaete worms and amphipod crustaceans were rare within samples. The crustacean amphipod *Corophium volutator* showed a clustered distribution within Rossmore Bay (Sites M9, M10, M11) with a single record in Brick Island Embayment (M13).

Biotopes assigned to mudflat sampling sites:

Table 3.6 shows the littoral sediment biotopes that have been assigned to the core sampling sites. Biotope assignment is not necessarily a straightforward process as in many cases the combination of sediment type and macroinvertebrate species found, do not fit neatly into the classification. In such cases, the biotopes that are the 'best-fit' are used.

Table 3.5 Benthic macrofauna recorded in 2008. Abundance per core (numbers/0.01m^2)

Taxa	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22
Phylum Annelida																						
Class Polychaeta																						
Hediste diversicolor				2		6																
Nepthys sp.		1							1			2	1			1					1	
Nepthys hombergi																				1		
Nepthys caecea									1													
Phyllodocidae indent.						1																
Spionid indent.		2			2	18	6	6	4					15								
Scolelepis squamata						2																
Arenicola marina		1																				
Ampharete acutifrons	1	10	13	9	11																	7
Class Oligochaeta																						
Oligochaetes								4						2								
Phylum Mollusca																						
Class Gastropoda																						
Hydrobia ulvae	4	19	7	3		1	1	2	12				5									
Littorina littorea		1																				
Class Bivalvia																						
Cerastoderma edule	1					1																
Scrobicularia plana						2							1								1	1
Macoma balthica												1										
Phylum Crustacea																						
Order Amphipoda																						
Corophium volutator									36	1	3		1									
Total No. Individuals	**6**	**34**	**20**	**14**	**13**	**31**	**7**	**12**	**54**	**1**	**3**	**3**	**8**	**17**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	**8**
Total No. Species/taxa	**3**	**6**	**2**	**3**	**2**	**7**	**2**	**3**	**5**	**1**	**1**	**2**	**4**	**2**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	**2**

Table 3.6 Littoral sediment biotopes assigned to the sampling sites. Biotopes were assigned after reviewing core-sampling data and qualitative results as shown in Table 3.3.

Site	Site Overview	Biotope	Rationale
M1 to M7	Silt clay sediment dominated by polychaete worms, and *Hydrobia ulvae*. Lugworm *Arenicola marina* and Common Cockle *Cerastoderma edule* observed but not found within core samples.	**LS.Lmu.MEst** Polychaete/bivalve dominated mid estuarine mud shores	An upper biotope code used to describe mid estuarine shores of silt clay or silty mud sediment with rich communities of polychaetes, bivalves & oligochaetes.
M8 – M9	Silt/clay sediment dominated by polychaete worms especially Lugworm *Arenicola marina.*	**LS.Lmu.MEst** Polychaete/bivalve dominated mid estuarine mud shores	As above.
M10 – M11	Soft mud (silt/clay) sediment, anoxic, fauna rare	**LS.LMu** Littoral Mud	Upper biotope code used as 'best-fit'
M12 & M16 – M22	Sediment varies from soft silt/clay, to sandy silt and silty sand (e.g. M20, M22). Fauna observed included Lugworm casts, *H. ulvae* & bivalve *Scrobicularia plana*.	**LS.Lmu.MEst** Polychaete/bivalve dominated mid estuarine mud shores	Higher biotope code used as a 'best-fit' because the recorded faunal community did not accurately match any of the specific littoral mud biotopes. This higher biotope describes a typical mid estuarine mud shore which has the potential to support a range of macroinvertebrate species.
		LS.LSa.MuSa Polychaete/bivalve dominated muddy sand shores	Higher biotope code used as a 'best-fit' where the sediment has more sand content e.g. Sites M20, M22.
13 & 14	Silt/clay sediment dominated by polychaete worms and bivalves e.g. *Nepthys* sp, Lugworm *Arenicola marina.*	**LS.LSa.MuSa** Polychaete/bivalve dominated muddy sand shores	Best-fit.
15	Sandy mud (sandy silt). Lugworm casts dominant but no fauna recorded within the core samples.	**LS.LSa.MuSa** Polychaete/bivalve dominated muddy sand shores	Best-fit.

Intertidal flora and fauna - Discussion

The 'hard shore' of the sampling sites is classified as a 'mixed substrata shore' (Fossitt, 2000), below which is littoral sediment (mudflat) classified as a 'mud shore.' This 'hard' and 'soft' element to the littoral habitat results in increased species diversity across the study area, as opposed to, for example, a mudflat habitat or embayment that exhibits a man-made edge to the upper littoral (e.g. sea wall) which is so often observed along coastlines. As well as exhibiting a diversity of flora and fauna, the 'hard' shore is an important habitat for wildfowl and wading birds that use this habitat for roosting and foraging during both high and low tide periods.

The benthic infauna species recorded are considered typical for a mid-estuarine shore which is subject to variable salinity but does not undergo the extreme changes in salinity which occurs at the head of an estuary where there is a large freshwater input. A diversity of species was recorded representing the major marine macroinvertebrate groups although polychaete worms dominated in terms of diversity, as found in previous annual surveys.

It is also important to note that a single core sample at each site may not reflect the true diversity or abundances that occur. (Note that standard methodology recommends 5 replicate samples at a site (Dalkin & Barnett, 2001). For example the Lugworm (*Arenicola marina*) was recorded in only one core sample but was recorded in the form of worm casts at the majority of sites. The lack of replication also contributes to the difficulty in assigning biotope codes to the core-sampling sites as a complete range of species and abundances for each site may not have been picked up.

Comparison of 2008 results with recent previous annual surveys

Limosa Environmental (2007) included a review of data from previous reports which date back to 2002. In the current report we therefore assess two different aspects of previous data:

(1) To compare and contrast results from three annual surveys (2006, 2007 and 2008), this review facilitated by the same methodology being adopted in each year.
(2) To compare results from the intertidal 2008 survey with the first available data-set (Biosphere Environmental Services, 2002). Note that an intertidal survey was not part of the scope undertaken by Biosphere Environmental Services (1998).

(1) Comparison of data 2006 – 2008.

- Hard Shore flora and fauna

In all three years the macroalgal community of the mixed substrata shoreline has been dominated by Egg Wrack (*Ascophyllum nodosum*) with variable amounts of Bladder Wrack (*Fucus vesiculosis*). The green macroalga *Enteromorpha* sp. is present in varying amounts in all years. Overall the macroalgal community does not appear to have changed in the past three years.

Similarly fauna show little difference across three years, species largely the same. One improvement and difference in 2008 was to identify the Littorinid Periwinkles to species level (not done previously) and three species are present (*Littorina rudis, L. obtusata* and *L. littorea*). The distribution of barnacles has remained clustered along the northern shore of Rossmore Bay together with a few other sites. The Blue Mussel (*Mytilus edulis*) has shown great variation and no trend is visible, this species occurring mainly within an intertidal mussel bed in Rossmore Bay, and not as a hard shore species. Littorinid Periwinkles were found at fewer sites in 2008 (7) as opposed to 2007 (10) or 2006 (12) but as the difference is not great, it could be due to random sampling and natural spatial variation.

- Core sampling macroinvertebrates

Benthic macroinvertebrate diversity has increased slightly over the past two years in comparison with 2006 (15 species in 2008; 16 species in 2007; 12 species in 2006). This is largely due to a greater number of

polychaete worms recorded in 2007 and 2008 with some species previously unrecorded e.g. O*phriotrocha puerilis* and *Cirratulus cirratus.* Other trends are listed below:

- In all years, data suggests that sampling sites within Rossmore Bay have a more diverse and abundant macroinvertebrate community compared to sites located around Rossmore Peninsula.

- Numbers of the Mud Snail have been highly variable across the years but their distribution is clustered within Rossmore Bay. This is not surprising given the 'muddier' nature of this area and relative shelter in comparison with Rossmore Peninsula.

- The Catworm *Nepthys* sp. continues to be a dominant member of the macroinvertebrate community. In most previous years the species *Nepthys hombergi* was recorded but in 2008 both *N. hombergi* and *N. caecea* were recorded.

- The crustacean amphipod *Corophium volutator* has only been recorded at Sites M9 – M11 in the past three years.

- The biotope 'Polychaete/bivalve dominated mid estuarine shore (LS.LMu.MEst)' has been assigned to the majority of sampling sites across the years.

(2) Long-term comparison 2002 – 2008.

Biosphere Environmental Services (2002) completed an intertidal survey as per the requirements of the landfill waste licence. It was during this survey that the location of 22 sampling sites was determined and the same sites have been sampled annually ever since. As the sampling methodology has remained largely similar to the present day, comparison of data sets is possible. Biosphere Environmental Services (2002) reported on samples taken in December 2001 therefore we can compare and contrast the results over a seven-year period.

- Hard Shore flora and fauna

There appears to have been little change in the flora and fauna communities of the mixed substrata shore during the seven year period. The macroalgae community was, and still is, dominated by Egg Wrack and Bladder Wrack. Overall, in 2008 Egg Wrack was the dominant macroalgae with varying amounts of Bladder Wrack. In contrast, Bladder wrack was largely the dominant macroalgae in 2001. As both species co-exist this contrast is not unusual and likely due to the randomness of sampling. There are some interesting and comparisons however. For example in 2001 Egg Wrack was the dominant macroalgae at Sites M3 and M5 and this was also the case in 2008. Site M2 was dominated by Bladder Wrack in both 2001 and 2008.

The red algae *Polysiphonia lanosa* was not recorded in 2001and may have appeared in the intervening time period.

Overall, the marine biotope '*Ascophyllum nodosum* and *Fucus vesiculosis* on variable salinity mid eulittoral rock' (LR.LLR.FVS.AscVS)' as assigned in 2008, would also be applicable to the 2001 survey results.

Faunal species diversity of the mixed substrata shore is largely similar across the years with barnacles, crustacean amphipods, shore crabs (*Carcinus maenas*) and periwinkles (*Littorinididae*) the major components. For example, barnacles occur mainly from Sites M1 to M8 (found in both 2001 and 2008) and Littorinid periwinkles are observed throughout the sites. Blue Mussels upon the shoreline were rather rare in 2001 (three sites) as they were in 2008 (one site). The presence of species such as the mud snail *Hydrobia ulvae* and amphipod *Corophium volutator* within shoreline quadrats in 2001 suggests a muddier substratum, although it was referred to as a 'stony substratum.'

- Core sampling macroinvertebrates

Comparing and contrasting data sets from 2001 and 2008 is difficult due to slightly different sampling methodology (e.g. different core size and sieve mesh size) (note that the current survey adopted current standard methodology).

Benthic macroinvertebrate diversity is greater in 2008 (15 species/taxa) as opposed to 12 species recorded in 2001. However, the differences may be due to species such as Spionid worms, which are often tiny and would pass through the 1mm-mesh sieve used in 2001 (a 0.5mm mesh sieve used in 2008). That said however, the 2001 survey reported greater frequency and densities of oligochaete worms which are also very small and it is likely that a proportion of these would also pass through a 1-mm mesh sieve during the sieving process. Oligochaete worms are indicators of organic enrichment and given their relative rarity in 2008, suggests a lower current-day level of sediment organic enrichment. This is likely to be linked to improvements in water quality of the North Channel.

Surprisingly, the Lugworm *Arenicola marina* was not reported within core samples in 2001 or mentioned within the report text as having been present (i.e. observed as casts). It is also not mentioned as a 'notable species' within the North Channel SAC site synopsis (Appendix 2.1). This may suggest a real increase in the species abundance and distribution over the years, although this must be treated be caution.

Overall conclusions of the intertidal flora and fauna survey

Both over a short time period (three years) and a longer time period (seven years) the intertidal flora and fauna of the study area, both hard shore and mudflat, have remained largely stable.

The combination of both a mixed substrata shoreline and soft sediment habitats results in the study area recording a good diversity of macrobenthic flora and fauna and there is a trend for increasing diversity over the past two years, as evidenced by the core sampling results.

3.3.2 Intertidal sediment analysis

Granulometry

Results of granulometry (sediment particle size) analysis are shown in Table 3.7.

Eight out of ten samples taken during 2008 comprised silt-clay sediment (fine mud). Of these, Sites SS1 and SS2 in Brick Island embayment and Sites SS4 and SS6 in Rossmore Bay had the greatest proportion of fine particles (i.e. particles < 63 µm in size). Sites SS7 and SS8 had the greatest proportion of fine sand.

The results for Sites SS1 and SS10 are comparable (Site SS10 being a control replicate of SS1).

In general, the visual and physical examination of sediment undertaken during core-sampling field work agrees with the results of the granulometry analysis e.g. Site M20 described in the field as 'sandy mud' and adjacent sample Site SS8 described as sandy mud following granulometry analysis.

Table 3.7 Granulometry Results 2008

Site	% Gravel > 2mm	% Coarse Sand 2mm – 710 µm	% Medium Sand 710 µm – 250 µm	% Fine Sand 250 µm – 63 µm	% Silt/Clay < 63 µm	Substrate Type
SS1	0	0.1	0.2	2.5	97.3	Silt-clay
SS2	0.1	0.2	0.3	4.2	95.2	Silt-clay
SS3	0.2	0.2	1.2	20.6	77.8	Silt-clay
SS4	0	0.1	0.8	7.8	91.3	Silt-clay
SS5	1.1	0.1	0.5	17.7	80.6	Silt-clay
SS6	0.2	0.4	0.3	6.7	92.4	Silt-clay
SS7	0.2	1.3	1.6	36.4	60.4	Sandy silt (sandy mud)
SS8	0.2	0.3	1.8	38.2	59.5	Sandy silt (sandy mud)
SS9	0.3	0.4	0.3	16.2	82.8	Silt-clay
SS10	0	0.2	0.4	3.3	96	Silt-clay

Sediment chemical analysis

Results of the sediment chemical analyses are shown in Table 3.8.

Table 3.8 Sediment Chemical Analysis

Parameter	Units	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10
Organic Carbon	%	2.00	2.20	<0.10	2.40	1.90	0.19	2.00	0.34	2.30	2.10
Kjeldahl Nitrogen	mg/g N	1.0	1.0	1.6	1.4	1.3	1.3	2.8	2.4	3.4	2.2
Arsenic	mg/kg	4.60	7.20	<1.00	6.3	5.00	9.50	7.30	4.90	6.00	5.10
Cadmium	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	mg/kg	11	14	18	12	9	11	13	9	13	12
Copper	mg/kg	8	10	11	17	28	13	9	7	10	8
Lead	mg/kg	14.81	16.92	22.91	19.76	17.63	17.08	15.96	12.9	15.08	14.27
Nickel	mg/kg	8.7	10.6	12.4	9.6	7.9	13.6	10.3	7.1	9.5	9.8
Zinc	mg/kg	46.4	56.0	77.5	58.2	45.6	53.8	54.2	41.0	49.7	47.9
Mercury	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25

% Organic Carbon
Carbon is a basic constituent of all organic compounds and the carbon in plant and animal tissue eventually breaks down to become organic matter. Organic content of sediment is closely correlated with sediment particle size; higher organic matter contents being found in muddy sediments (Durrell et al., 2005).

Organic carbon values within the ten sediment samples of 2008 ranged from <0.10% (SS3) to 2.40% (SS4). As values greater than 5% generally indicate a level of organic enrichment (e.g. Hansen & Kristensen, 1997), results of the 2008 sampling suggest a relatively low sediment organic content with no organic enrichment. Further, the 2008 results are also significantly lower than reported in recent previous years as illustrated by Figure 4.

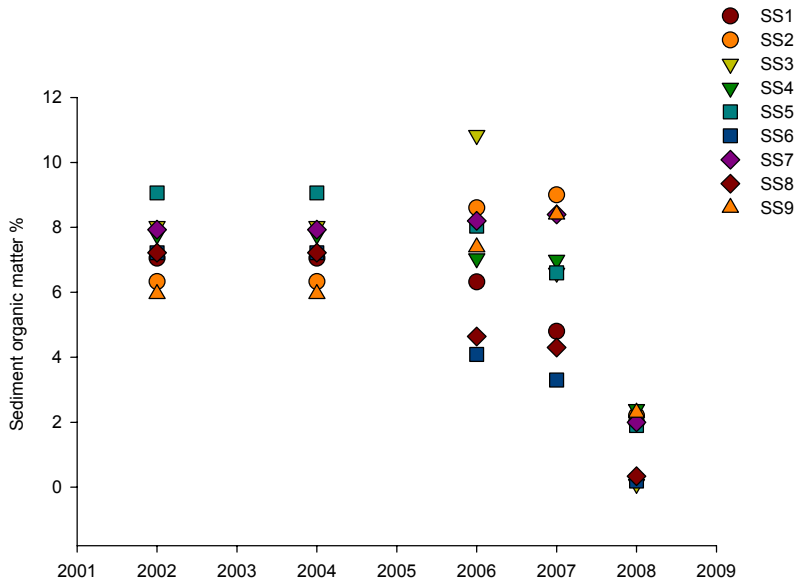


Figure 4. Sediment organic carbon content (%) – results for 2002, 2004, 2006, 2007 & 2008.

Kjeldahl Nitrogen
Kjeldahl Nitrogen is a measure of ammonia plus organic nitrogen. The un-ionised ammonium ion (NH^3) is regarded as the most toxic form of ammonia and generally increases in aquatic environments with lower levels of dissolved oxygen and reduced salinity. The source of ammonia to tidal waters is linked to sewage treatment plants, agricultural run-off and industrial effluents.

Levels of Kjeldahl Nitrogen within 2008 sediment samples ranged from 1.0 mg/g N (SS1 & SS2) to 2.8 mg/g N (SS7). SS7 also recorded the greatest values in the 2007 analysis and has shown a trend for higher levels compared to other sites in other previous surveys (Table 3.9). However, the levels recorded are considered within a normal range for an estuary that is subject to a variety of anthropogenic influences.

Table 3.9 Kjeldahl Nitrogen (mg/g N) - current and previous results.

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9
2008	1.00	1.00	1.60	1.40	1.30	1.30	2.80	2.40	3.40
2007	1.87	2.28	2.729	2.563	2.008	0.967	2.822	1.531	1.047
2006	1.04	0.98	1.10	0.98	0.98	0.49	1.06	0.66	0.99
2004	1.80	1.25	2.18	2.38	1.70	1.57	2.13	1.50	1.45
2002	1.80	1.25	2.18	2.38	1.70	1.57	2.13	1.50	1.45

Metals

There are no national sediment quality guidelines (SQG's) for *in-situ* marine sediment quality. Therefore the results of the sediment metal analyses were compared against national standards drawn up for dredged sediments (Cronin *et al.,* 2006) and other SQG's drawn up by the Netherlands, UK, Norway, Canada and Australia. These standards are shown in Appendix 3.1.

- Arsenic

Arsenic values within all 2008 sediment samples are below all threshold guidance levels shown in Appendix 3.1, with the exception of Site SS7 which just surpasses the stringent Canadian CCME standards (1992). 2008 levels are however, significantly greater than recorded in previous annual surveys (Table 3.10).

Table 3.10 Arsenic levels (mg/kg) - current and previous results.

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9
2008	4.60	7.20	<1.00	6.30	5.00	9.50	7.30	4.90	6.00
2007	0.313	0.328	0.48	0.237	0.434	0.37	0.113	0.175	0.303
2006	2.21	2.32	1.04	2.68	1.70	2.42	1.90	2.80	2.70
2004	1.88	2.15	3.04	1.67	1.23	0.93	1.17	2.67	0.86

- Cadmium

All sediment samples contained levels below 1 mg/kg but analysis is not sensitive enough to ascertain lower levels and compare with stringent sediment quality criteria.

- Chromium

2008 results (range 9 – 18 mg/kg) are significantly lower than those recorded in 2007 (range 6.10 – 49.60 mg/kg) and more in line with the 2006 results (range 7.8 – 11.2). All values recorded in 2008 are below all threshold guidance levels shown in Appendix 3.1.

- Copper

2008 results range from 7 to 28 mg/kg. All samples are below the lower level Irish SQG's for dredged sediment. Site SS5 (28 mg/kg) surpasses the stringent Canadian CCME standards (18.7 mg/kg) and the UK MAFF In-house threshold values (20 mg/kg). Overall, 2008 results for copper are significantly lower than those recorded in 2007 (range 21.60 – 49.10 mg/kg).

- Lead

2008 results (range 12.9 – 22.91 mg/kg) are all below all threshold guidance levels shown in Appendix 3.1 and are in a similar range to results recorded in previous years.

- Nickel

2008 results range from 7.1 (SS8) – 13.6 (SS6) mg/kg. All results, with the exception of SS3 and SS6, are below threshold guidance levels shown in Appendix 3.1. Sites SS3 and SS6 (levels of 12.4 and 13.6 mg/kg respectively) are above the stringent UK MAFF in-house guidance threshold of 10 mg/kg.

2008 results are significantly lower than results recorded in 2007 (range 6.6 – 34.50 mg/kg).

- Zinc

2008 results (range 41.0 – 77.5 mg/kg) are generally within threshold guidance levels with the exception of sample SS3 which surpasses the UK MAFF in-house guidance threshold of 65 mg/kg. 2008 results are in line with those recorded in 2006; levels surprisingly low in 2007 (Table 3.11). However, recent surveys do suggest lower levels than occurred previously – note much higher levels recorded in 2004.

Table 3.11 Zinc levels (mg/kg) - current and previous results.

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9
2008	46.4	56.0	77.5	58.2	45.6	53.8	54.2	41.0	49.7
2007	2.65	2.06	2.98	2.98	2.48	0.60	2.50	2.94	2.92
2006	44.5	54.2	43.2	44.3	53.0	48.8	45.0	38.6	42.9
2004	89.0	124.6	149.6	134.8	109.0	90.2	119.8	112.8	110.7

- Mercury

All sediment samples contained levels below 0.25 mg/kg but analysis is not sensitive enough to ascertain lower levels and hence compare with stringent sediment quality criteria.

Overall conclusions of the chemical sediment analysis

Results of sediment chemistry analysis suggest that levels of organic enrichment at sampling sites have decreased within recent years and particularly within the last 12 months. Whether this trend is a result of changes in landfill procedures (as a result of landfill closure) or a result of other natural and/or anthropogenic factors is difficult to ascertain. This result is in line with general improvements in water quality in the North Channel in recent years (See Section 6).

In terms of metals analysis, no result stood out in terms of a particularly high level. Comparison of results across recent years reveals how metal levels can be highly variable between years.

There is no apparent pattern with regards site location and sediment metal content. The highest levels of chromium, lead and zinc were recorded at Site SS3, while the highest levels of Kjeldahl nitrogen and nickel were recorded at SS7.

Appendix 3.1

Sediment Quality Guidance Criteria

There are currently no Irish sediment quality guidelines (SQG's) for *in-situ* sediment quality. Therefore, as a national standard, we use the guidance levels for contaminant levels in dredged sediment (Cronin *et al.,* 2006). The lower level (Level 1) defines a concentration (i.e. guidance value) of a contaminant in sediment below which biological effects would not be anticipated. The upper level (Level 2) defines a contaminant concentration above which biological effects are anticipated to occur.

Irish SQG's for dredged sediment (Cronin *et al.,* 2006)

	Units	Lower level	Upper Level
Arsenic	mg/kg^{-1}	9	70
Cadmium	mg/kg^{-1}	0.7	4.2
Chromium	mg/kg^{-1}	120	370
Copper	mg/kg^{-1}	40	110
Lead	mg/kg^{-1}	60	218
Mercury	mg/kg^{-1}	0.2	0.7
Nickel	mg/kg^{-1}	21	60
Zinc	mg/kg^{-1}	160	410

Further SQG's have been developed around the world and we also refer to these in this assessment.

(a) The UK MAFF In-house standards, the Dutch Target values and the Norwegian Classification are all standards for dredged sediment.

(b) The Canadian CCME (1999) and the ANZECC/ARMCANX Guidelines (2000) were published as part of freshwater and marine water quality guidelines.

(a)

	Units	Dutch Target Values	Dutch Intervention Values	UK MAFF In-house	Norwegian Class 1
Arsenic	mg/kg^{-1}	29	55	40	<20
Cadmium	mg/kg^{-1}	0.8	12	0.2	<0.25
Chromium	mg/kg^{-1}	100	380	20	<70
Copper	mg/kg^{-1}	35	190	20	<35
Lead	mg/kg^{-1}	85	530	25	<30
Mercury	mg/kg^{-1}	0.3	10	0.15	<0.15
Nickel	mg/kg^{-1}	35	210	10	<30
Zinc	mg/kg^{-1}	140	720	65	<150

(b)

	Units	Canadian CCME (1992)	Australian ANZECC/ARMCANZ (2000)	
			high	Low
Arsenic	mg/kg^{-1}	7.24	20	70
Cadmium	mg/kg^{-1}	0.7	1.5	10
Chromium	mg/kg^{-1}	52.3	80	370
Copper	mg/kg^{-1}	18.7	65	270
Lead	mg/kg^{-1}	30.2	50	220
Mercury	mg/kg^{-1}	0.13	0.15	1
Nickel	mg/kg^{-1}	-	21	52
Zinc	mg/kg^{-1}	124	200	410

4.0 WATERBIRD SURVEY AND ASSESSMENT

4.1 Methodology

The avian assessment comprised the following components:

(1) Consultation of relevant literature and local records pertaining to the study area.

(2) Waterbird surveys of two survey zones (Zones A and B) following established methodology for East Cork Landfill annual monitoring:-
- Zone A comprises Rossmore Bay from its innermost reaches westwards to its 'junction' with the North Channel
- Zone B comprises the mudflats partially enclosed by the Brick Island Peninsula (Brick Island Embayment) (Figure 5).

Surveys were undertaken on 26/11/08, 28/11/08, 10/12/08 & 12/12/08. On each visit five hours of waterbird observations were made, alternating between Zone A and Zone B. The 30-minute observation time was split into 20 minutes for recording observations and 10 minutes for walking between vantage points.

Waterbird surveys were carried out using a telescope (20-60 x zoom lens) and binoculars (x 50) and in (almost all cases) calm and clear weather conditions.

(3) Bird surveys of the North Channel including Rossmore Bay and the Brick Island embayment.

On two occasions (12th and 18th September 2008) waterbird surveys were undertaken within four survey zones A-D, as shown in Figure 5. These zones aimed to cover all areas of the North Channel around Rossmore Peninsula.

(4) Review of annual count data from the Irish Wetland Bird Survey (I-WeBS).

Waterbirds (wildfowl and wading birds) of coastal and inland wetlands are counted annually during winter months as part of the Irish Wetland Bird Survey (I-WeBS) coordinated by BirdWatch Ireland. The most recent I-WeBS data for Cork Harbour was obtained, together with relevant sub-site data for count areas located close to Rossmore Peninsula. This data was reviewed together with that obtained during previous annual surveys and other published data sources (e.g. Crowe, 2005; Boland et al., 2008). Sub-site data was assessed in terms of its conservation importance in the context of the entire North Channel and the North Channel was assessed in terms of its conservation importance as part of the entire coastal wetland site of Cork Harbour.

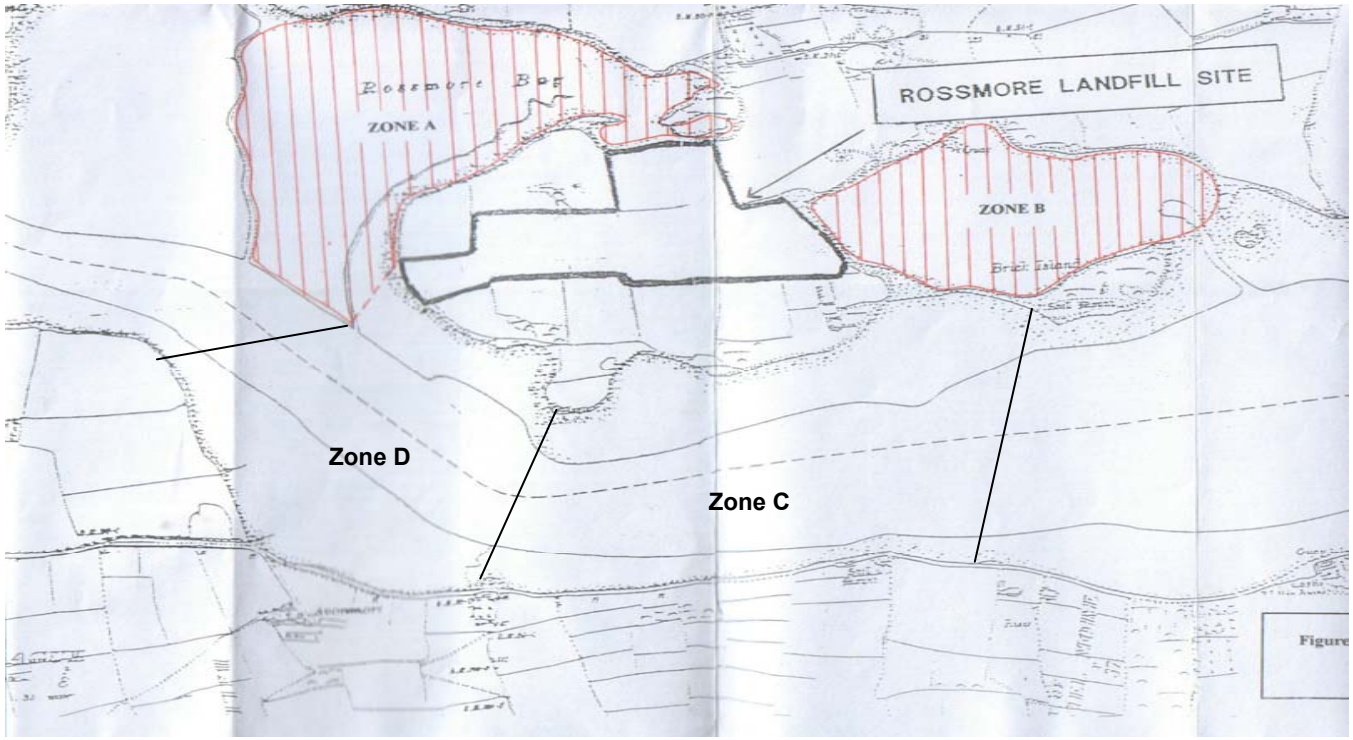


Figure 5 Estuarine Bird Survey Zones A-D

4.2 Survey Results & Discussion

Throughout the text bird species common names are used. Bird species and their conservation importance are assessed with reference to legislation and national red data lists as explained in Appendix 4.1.

A list of all bird species recorded during surveys is shown in Appendix 4.2. This reveals that three Annex I species were recorded (Little Egret, Golden Plover & Common Tern). Seven red-listed species and 17 amber-listed species of conservation concern were recorded. These listed species differ from previous annual reports as the conservation criteria and species listing were updated in 2007 (Lynas et al., 2007). The criteria under which red and amber species are listed are given in Appendix 4.2.

4.2.1 Waterbird surveys around Rossmore Peninsula (Zones A-D)

Data from the bird surveys of Zones A, B, C & D are given in Table 4.1. In contrast to I-WeBS counts which are undertaken at high water, this data shows the bird community recorded during a low water period (either side of low tide). The counts were undertaken in early autumn as wintering birds were arriving at the site from breeding grounds.

Because of the timing of the survey, we recorded a breeding species of seabird, Common Tern – an Annex I species (EU Bird's Directive) that breeds in small numbers within Cork Harbour and was recorded foraging over the North Channel. Common Terns spend summer in Ireland (to breed) then are thought to migrate down the western seaboard of Europe and Africa for winter (Wernham et al., 2002).

The closest breeding colony of Common Terns to Rossmore Peninsula is Marino Point. Common Terns have been known to breed on disused barges between Marino Point and Little Island and on the Martello Tower near Marino Point (Wilson *et al.,* 2000). Numbers have varied across the years but peaked at 102 pairs in 1995. In 2001 they deserted the site for no obvious reason, and the colony moved to the Ringaskiddy area (P. Smiddy *pers. comm*.) but a breeding colony was confirmed there again in 2008 (L. J. Lewis pers. obs).

The wading bird species Whimbrel were observed on two occasions – this is a staging species (stop-over on the way to another area) as opposed to species that winter within Cork Harbour.

Of note was the significantly lower number of gull species, in contrast to recent years when large numbers (thousands) flocked to the area because of the active landfill site.

Table 4.1 Data from the North Channel bird surveys (including Rossmore Bay and the Brick Island Embayment; Zones A, B, C & D).

	12th September 2008				18th September 2008			
	Zone A	**Zone B**	**Zone C**	**Zone D**	**Zone A**	**Zone B**	**Zone C**	**Zone D**
Time	12:45	13:45	13:20	13:00	11:00	12:00	11:40	11:25
Tidal time	LT+2	LT+4	LT+3	LT+3	LT-4	LT-3	LT-3	LT-3
Cormorant				3			1	4
Little Egret		7	3		2	6		12
Grey Heron			1			2		6
Oystercatcher	18	3	42	24		22	20	31
Dunlin		8						
Black-tailed godwit	86			9	5			1
Whimbrel			2		1			
Curlew	21	4	2	3	3	13	2	6
Redshank	13	10	13	11	44		5	7
Greenshank		1				1	1	2
Turnstone	2						2	
Black-headed Gull	18	19	2	7	8	10	11	12
Herring Gull	4		1	1		1	1	2
Lesser Black-backed Gull	3		1				1	
Common Tern				8				
TOTAL	**165**	**52**	**67**	**66**	**63**	**55**	**44**	**83**

4.2.2 Waterbird surveys of Zones A and B

Count data from the repeat surveys of Zone A (Rossmore Bay) and Zone B (Brick Island Embayment) are shown in Appendix 4.3. The data tables show waterbird species recorded together with the time of survey, tidal time and the stage of the tide in relation to the following four tidal periods:

Tide 1: Initial tidal ebb
Tide 2: tidal ebb approaching and including low water,
Tide 3: initial tidal inflow, and
Tide 4: tidal inflow approaching high water.

As I-WeBS counts are undertaken at high tide, this study aimed to record waterbird numbers during times of low water and hence the majority of counts were undertaken during tidal stages 2 and 3. Data for selected waterbird species were analysed in two ways (1) average numbers across the same tidal stage were calculated; (2) peak numbers during a tidal stage where identified (Table 4.2).

Table 4.2a Mean bird numbers (± SD standard deviation) within **Zone A** during tidal stage 2 (tidal ebb approaching and including LT) and Stage 3 (LT and initial tidal inflow); plus peak number recorded during the tidal stages during any one count (n) is the number of times the species was recorded within the survey zone during tidal periods.

	Zone A			
	Tidal Stage 2	**Tidal Stage 2**	**Tidal Stage 3**	**Tidal Stage 3**
	Mean ± S. D (*n*)	Peak No	Mean ± S. D (*n*)	Peak No
Shelduck	41 ± 24 (4)	63	27 ± 26 (9)	63
Oystercatcher	15 ± 6 (4)	25	18 ± 9 (11)	46
Dunlin	319 ± 179 (3)	526	457 ± 423 (11)	1144
Black-tailed godwit	33 ± 1 94)	35	17 ± 11 (7)	33
Curlew	4 ± 2 (4)	6	4 ±2 (11)	9
Redshank	69 ± 5 (4)	76	77 ± 24 (11)	108

Table 4.2b Mean bird numbers (± SD standard deviation) within **Zone B** during tidal stage 2 (tidal ebb approaching and including LT) and Stage 3 (LT and initial tidal inflow); plus peak number recorded during the tidal stages during any one count (n) is the number of times the species was recorded within the survey zone during tidal periods.

	Zone B			
	Tidal Stage 2	**Tidal Stage 2**	**Tidal Stage 3**	**Tidal Stage 3**
	Mean ± S. D (*n*)	Peak No	Mean ± S. D (*n*)	Peak No
Shelduck	-	-	-	13
Oystercatcher	8 ± 4 (4)	13	11 ± 5 (12)	20
Dunlin	-	6	190 ± 267 (3)	498
Black-tailed godwit	-	9	9 ± 4 (8)	15
Curlew	-	9	6 ± 6 (10)	15
Redshank	22 ± 10 (4)	30	42 ± 14 (12)	69

Table 4.2c Peak numbers of selected waterbird species - across all tidal stages (number in brackets refers to tidal stage).

	Zone A	**Zone B**
	Peak Number recorded (tidal stage)	
Shelduck	95 (4)	71 (4)
Oystercatcher	46 (3)	20 (2)
Dunlin	1300 (3)	824 (4)
Black-tailed godwit	35 (2)	15 (2)
Curlew	8 (3)	12 (3)
Redshank	108 (3)	69 (3)

The following points are evident from the data tables and general observations:-

- Greater numbers of waterbirds were observed within Zone A (Rossmore Bay) than Zone B (Brick Island Embayment; not particularly surprising given the greater size (area) of Rossmore Bay.

- Within Zone A, average and peak numbers were relatively consistent across tidal stages 2 and 3 for most species analysed; the exception being Dunlin that were most abundant during tidal stage 3 (initial tidal inflow) – during this period large numbers of Dunlin were observed foraging along the tide edge and the tide flowed into the bay.
- Within Zone B waterbirds were most abundant during tidal stage 3 (initial tidal inflow) – the majority observed foraging along the tide edge as it flowed into the area.
- Peak numbers (Table 4.2c) show that waterbirds in general are most abundant during tidal stages 2 and 3. The exception is Dunlin that peaked in abundance within Zone A during tidal stage 3 (tidal inflow) but at tidal stage 4 within Zone B – this is most likely due to the fact that these birds foraged along the tide edge within Rossmore Bay (stage 3) then as the tide moved up, birds moved across to Zone B to forage along the tide edge; the tidal inflow rate being much slower within this area – the partially enclosed nature of this embayment (narrow entrance) means that the tide ebbs much faster and floods more slowly, resulting in this mudflat being exposed for a greater length of time.
- At high tide within Zone A, relatively low numbers of birds roost upon the shore. The Oystercatcher roost identified during the 2006 and 2007 survey (on the shore in the south-western extent of the survey zone) was noted again during 2008.
- Few birds roost along the northern shore of Zone A (south of the quarry), possibly due to the degree of exposure or disturbance (quarry) along this shore.
- Greatest waterbird activity is observed upon either the ebbing or flooding tide with a large proportion of the shorebirds following the tide edge to feed.
- Large numbers of foraging wading birds and waterfowl usually occurred outside the defined boundary of Zone A towards Weir Island e.g. Shelduck, Dunlin and Oystercatchers.
- Red-breasted Mergansers were only recorded within Zone B within the water channel.

Comparison with previous years

- A total 16 waterbird species (excluding gull) were observed within Zone A. Shelduck, Oystercatcher, Knot, Dunlin, Redshank and Curlew were the most frequently recorded, occurring in nearly all counts. This result is reasonably consistent with that found in previous years.

- Lapwing and Golden Plover were not recorded within Zones A and B during 2008 or 2007. This contrasts to 2006 when both species were recorded in large numbers within Zone B. Large numbers of Lapwing (e.g. 790) were also reported in 2005 (Fehily Timoney, 2005). Examining earlier data (2002/03) suggests highly variable numbers but comparison between years is confounded by counts being undertaken at differing times of the tidal cycle.

- One of the most striking contrasts to previous surveys was the very low number of gulls species recorded in 2008. This is almost certainly due to the closure of the landfill to waste acceptance – gulls and crows known to be attracted by active landfills (Watson & Hack, 2000). In previous surveys up to several thousand gulls were recorded within the survey areas, in contrast 2008 data shows only very low numbers and very often no gulls were recorded at all.

- A total 14 waterbird species were observed within Zone B. Redshank, Oystercatcher and Curlew were the most frequently recorded. This result is reasonably consistent with that found in 2007 and previous years.

- Several species were recorded in less frequency and abundance during the 2008 surveys than in recent previous surveys. Lower numbers of Black-tailed godwits were recorded overall e.g. peak count of 35 in Zone A and 15 in Zone B in comparison with 80 and 18 (Zones A & B respectively) in 2007. In particular, Black-tailed godwits occurred less frequently within Zone B than previous years. Curlews were also noticeably less frequent during 2008. Table 4.3 shows data from recent previous surveys (2005 – 2008). Unfortunately comparison of data prior to 2005 is difficult as counts were taken at different times of the tidal cycle, precluding any meaningful comparisons or conclusions. However, Table 4.3 shows that numbers of Black-tailed godwits have declined somewhat in comparison with the three previous years. Numbers for Curlew are variable across the years but a slight decline in the current years is also evident. Nationally there has been a decline in Curlew numbers but Black-tailed godwits have been increasing (Crowe et al., 2008). These trends should be monitored in future years.

Table 4.3 Peak numbers of selected waterbird species recorded within Zones A and B during 2008 and in recent previous annual surveys. Red = suggested trend for decline; green = possible increase; blue = stable; black = no trend.

	Survey Zone	Black-tailed godwits	Curlew	Dunlin	Redshank	Oystercatcher	Shelduck
2008	A	35	8	1300	108	46	95
	B	15	12	824	69	20	71
2007	A	80	16	470	97	32	78
	B	18	22	29	50	22	1
2006	A	60	14	200	139	80	97
	B	74	21	353	51	25	12
2005	A	30	103	685	160	233	181
	B	79	10	400	40	25	15

- Oystercatchers appear to have declined within Zone A in recent years (Table 4.3) although such a conclusion is speculative as this species can range widely and utilise a variety of intertidal (mudflats, rocky shores) and terrestrial habitats (grassland) and hence trends are difficult to confirm.

- Overall, Redshanks are the most frequently occurring wading bird species and the 2008 numbers are consistent with previous years count data (Table 4.3) with a relatively stable wintering population.

- Comparing peak numbers of Dunlin 2005-2008 reveals a possible increase in numbers although numbers are highly variable and Zone B only recorded the species during one count in 2007. 2008 numbers however are almost double those recorded in 2005. Dunlin are thought to be declining on a national level (Crowe et al., 2008). The data trend should be monitored in future years.

4.2.3 Review of data from the Irish Wetland Bird Survey (I-WeBS)

The North Channel is a count sub-site of the entire coastal wetland site of Cork Harbour, but this area in itself, due to the large size, is also split into a number of separate count sub-sites:

- North Channel – Ballintubbrid (W 810 702) – the largest sub-site and running directly south of Rossmore peninsula.
- Weir Island (W 810 710)
- Brick Island (W820 700)
- Ballintubbrid (W840 702)
- Rathcoursey & Ahanesk (W870 700)

The sub-sites that are closest to East Cork Landfill are Brick Island (directly east), Ballintubbrid (south) and Weir Island (to the west). The most recent I-WeBS data (2002/03 – 2006/07) for these sites is shown in Appendix 4.4.

Sub-site: North Channel - Ballintubbrid

This is the largest sub-site in the North Channel, extending from Ballintubbrid in the east, to Fota Island in the west. This sub-site supports 26 regularly occurring waterbird species including Annex I species Little Egret and Golden Plover. Current data shows four species occur in nationally-important numbers: Shelduck, Pintail, Red-breasted Merganser and Redshank. Good numbers of Wigeon, Oystercatcher, Dunlin and Black-tailed Godwit are also recorded.

Numbers of total waterbirds within this sub-site have been relatively consistent across the period 2004/05 – 2006/07 (at around 2,000 waterbirds). A decline in total numbers since 2002 may have occurred; but an

examination of longer-term data (from previous annual reports) is not possible because data obtained in previous years did not include total waterbird numbers.

Sub-site: Weir Island

Weir Island supports 17 regularly occurring waterbirds during winter (Appendix 4.4) and is a known major roost site within Cork Harbour (Hutchinson & O'Halloran, 1984).

The island is particularly important for Shelduck, Oystercatcher, Golden Plover and Dunlin whose 5-year average numbers are 117, 184, 245 and 315 respectively. Redshanks are also recorded in good numbers (five-year average of 261).

Average total number of waterbirds (average over 5 years) is 1,475 which accounts for over 20% of the average number of waterbirds recorded within the entire North Channel subsite. In terms of increasing or decreasing total numbers, data for total waterbirds within this sub-site shows no observable trend in either direction although a particularly low count was recorded for 2006/07 should prompt further examination of data in the future.

Sub-site: Brick Island

Brick Island is also an important roost site, and this relatively small sub-site regularly supports 16 waterbird species during winter (Appendix 4.4). The most numerous waterbirds are Dunlin, Black-tailed godwits and Redshanks. In terms of increasing or decreasing total numbers, data for total waterbirds within this sub-site shows no observable trend in either direction. Numbers are highly variable (range 205 – 1,026) across the five-year period with a relatively high overall count in 2006/07 suggesting no overall trend for declines.

Brick Island Embayment with the tree-covered Brick Island in the distance.

Entire Count Unit: The North Channel (sub-sites combined)

- Waterbirds that occur in internationally important numbers

A review of data (2002/03 – 2006/07) shows that the North Channel does not currently support any waterbird species in internationally important numbers. Previous reviews that reported internationally important numbers of Black-tailed godwits were correct at the time but the international threshold has since been raised to 470 birds (Wetlands International, 2006) resulting in the North Channel sub-site wintering population no longer qualifying.

- Waterbirds that occur in nationally important numbers.

Data (2002/03 – 2006/07) shows that the North Channel supports 8 species in nationally important numbers: Shelduck, Wigeon, Pintail, Red-breasted Merganser, Dunlin, Black-tailed Godwit, Redshank and Greenshank. This result is consistent with previous years.

- Total waterbird numbers wintering within the North Channel

Recent I-WeBS data shows that the North Channel supports 33 regularly occurring waterbird species during winter including three regularly-occurring species that are listed on Annex I of the EU Birds Directive: Little Egret, Golden Plover and Bar-tailed Godwit.

Total waterbird numbers for the North Channel are shown in Table 4.4 (current data plus data obtained in previous annual monitoring). The five-year average of 6, 791 waterbirds equates to just over 20% of the waterbirds occurring across the entire Cork Harbour wetland site during winter, highlighting its importance.

Table 4.4 Total waterbird numbers and the five-year average recorded for the North Channel.

	2002/03	2003/04	2004/05	2005/06	2006/07	Average 2002/03 – 2006/07
North Channel (sub-sites combined)	7631	8, 728	6,293	6,509	4,793	6, 791

In terms of increasing or decreasing total numbers, data for total waterbirds (above) perhaps suggest a decline in overall numbers. However, examination of longer-term data (from previous annual reports) is not possible because data obtained in previous years did not include total waterbird numbers.

- Waterbird species showing a trend for increase or decrease within the North Channel

To assess species trends over a longer time period, we assessed data obtained during previous annual monitoring of East Cork Landfill (2001/02) together with the recent data for 2002/03 – 2006/07.

Data in Table 4.5 suggests a possible decline in the numbers of Pintail, Dunlin and Black-tailed Godwit within the North Channel. This is consistent with a reported national decline in Pintail and Dunlin, the latter in excess of 5% per year between 1994/95 – 2003/04 (Crowe et al., 2008). However, Black-tailed godwits increased in number nationally, over a similar period (Crowe et al., 2008).

Table 4.5 also shows that numbers of Wigeon may be showing a trend for increase while numbers of Little Egret have increased; the latter a species that has naturalised and spread rapidly across Ireland in recent years, both as a breeding and wintering bird.

Table 4.5 Mean peak counts of selected waterbirds in the North Channel (1998/99 – 2006/07).
Blue = apparent increase; green = possible increase?; red = apparent decline, black = no trend.

Species	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Little Egret	6	11	33	44	34	27
Shelduck	458	902	798	589	455	311
Wigeon	422	894	1295	883	1184	575
Pintail	66	73	45	20	14	1
Red-breasted Merganser	3	41	44	45	42	33
Oystercatcher	352	330	661	348	555	245
Golden Plover	600	762	1560	1264	502	416
Lapwing	832	553	884	586	997	694
Dunlin	317	1317	1545	318	616	1002
Black-tailed Godwit	800	408	92	394	287	148
Redshank	215	851	468	497	468	456

- *The relative importance of three sub-sites within the North Channel*

Table 4.6 shows the total annual waterbird numbers and the five-year average for the three North Channel sub-sites considered within this report, plus the North Channel count unit as a whole.

Table 4.6 Total waterbird numbers and the five-year average at the North Channel and at three sub-sites.

	2002/03	2003/04	2004/05	2005/06	2006/07	Average
North Channel sub-sites combined	7631	8, 728	6,293	6,509	4, 793	6, 791
North Channel – Ballintubbrid	4,342	3,972	2,121	2,121	2,061	2,923
Weir Island	1,140	1,610	2,473	1,526	624	1,475
Brick Island	1,026	881	205	322	764	640

The North Channel – Ballintubbrid sub-site supports on average just over 40% of the waterbirds in the entire North Channel. Weir Island supports just over 20% and Brick Island, a relatively small sub-site, supports about 9.5% of the average numbers of waterbirds in the North Channel as a whole.

Table 4.7 gives average peak counts of selected bird species within the three sub-sites reviewed above together with the average peak counts for the entire North Channel count unit.

This table highlights the importance of the North Channel – Ballintubbrid sub-site which in itself supports nationally important numbers of four waterbird species (Shelduck, Pintail, Red-breasted Merganser & Redshank) which represent over 60% of the Shelduck and Redshank respectively and 100% of the Pintail and occur within the entire North Channel count unit.

Weir and Brick Islands are comparatively smaller count sub-sites but are also extremely valuable sites in themselves. For example, counts for Weir Island represent 47% of the total wintering population within the North Channel area. Similarly counts of Dunlin for Brick Island represent 22% of the total wintering population within the North Channel.

Table 4.7 Current I-WeBS data (2002/03 – 2006/07) for Cork Harbour North Channel showing average counts of selected bird species within three sub-sites (North-Channel – Ballintubbrid, Weir Island and Brick Island) and the average counts for the North Channel count unit as a whole. * National Importance.

Species	North Channel – Ballintubbrid	Weir Island	Brick Island	North Channel Entire Count Unit
Shelduck	407*	117	25	611*
Wigeon	329	75	21	966*
Pintail	31*	-	-	31*
Red-breasted Merganser	35*	-	-	41*
Dunlin	269	315	213	960*
Black-tailed Godwit	114	44	50	266*
Redshank	339*	261	59	548*

- *The North Channel as a sub-site of the Cork Harbour wetland complex*

Total waterbird data for Cork Harbour (2001/02 – 2005/06) is shown in Appendix 4.4 and recent summary data (taken from Boland et al., 2008) is shown in Table 4.8 below. Note that totals are different in the two data-sets as data calculations are continually changing as more data becomes available.

Table 4.8 Total waterbird data – Cork Harbour (2002/03 – 2006/07) plus data for the same period for the North Channel.

	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Cork Harbour	31, 741	29, 551	30, 368	31, 175	26, 923	19, 669
North Channel sub-sites combined	-	7631	8728	6293	6509	4793
% contribution of North Channel populations to entire Cork Harbour population	-	25	28	20	24	24

A five-year average of 29, 504 waterbirds (2002/03 – 2006/07) currently places Cork Harbour as the 6th most important wetland in the country (Boland et al., 2008).

Comparing data for the North Channel against the entire coastal site of Cork Harbour reveals that the North Channel supports around a quarter of the total wintering waterbird population of Cork Harbour (Table 4.8). This result is reasonably consistent with previous data analyses; for example, Fehily Timoney (2005) reported that North Channel waterbird populations accounted for between 21 – 40% of the total Cork Harbour populations for the period 1998/99 to 2002/03.

Importance of Cork Harbour for Birds

Cork Harbour is the largest estuarine habitat on the south coast of Ireland (Hutchinson & O'Halloran, 1984). The large expanses of intertidal mudflats and associated wetland habitats of Cork Harbour provide important feeding and roosting areas for migratory wintering wading birds and wildfowl (Smiddy *et al.,* 1995). Consequently the main intertidal areas of Cork Harbour are designated as a Special Protection Area (SPA) (Site Code 4030). The site qualifies for designation because it is an internationally important wetland site under established criteria of the Ramsar Convention Bureau (1984) including that it regularly supports in excess of 20,000 waterbirds during winter.

Currently the sixth most important wetland site in the country, Cork Harbour supported an average 29,509 waterbirds between 2002 and 2007 (Boland et al., 2008). Cork Harbour also supports wintering populations of Golden Plover and Little Egret, species listed on Annex I of the EU Birds Directive together with Little Egret and Common Terns, during the breeding season (Wilson *et al.,* 2000). In addition, the harbour supports nationally or internationally important numbers of several waterbird species.

4.3 Final conclusions of the waterbird surveys and assessment

Whilst waterbird numbers within Zones A and B (Rossmore Bay and Brick Island Embayment) show variation across the years, many species appear to have relatively stable wintering populations (e.g. Redshank). However, numbers of Black-tailed godwits and Curlew appear to have declined in recent years. In contrast numbers of Dunlin appear to have increased. These trends should be investigated in future years although it must be considered that the count data recorded represents a 'snap-shot' of the wintering populations and only further data collection (i.e. more counts) could confirm such trends with any certainty.

Supporting over a quarter of the total waterbirds that winter in Cork Harbour, the North Channel is an important part of the overall wetland site of Cork Harbour and as this report has shown, several important sub-sites within the North Channel are located close to East Cork Landfill.

While assessing trends in data is difficult due to differing types of data-sets obtained in different years and also wider problems with data collection in Cork Harbour (e.g. missing data sets) (Crowe, 2005) some trends are emerging such as apparent declines in recent years of wintering Pintail and Dunlin within the North Channel. Note that the latter decline (Dunlin) is in contrast to the data trend for Rossmore Bay (see above). However, these noted declines are consistent with national trends.

Whether wintering waterbird numbers in future years increase due to e.g. a lower number of gulls and crows associated with an active landfill (and hence lower competition), remains to be seen, and only future monitoring will be able to assess such trends.

Appendix 4.1

Legislation concerning birds:

Council Directive of 2 April 1979 on the Conservation of Wild Birds (79/409/EEC) ('Birds Directive') :- this directive relates to the conservation of all species of naturally occurring birds in the wild. The directive lays down protection, management and control of these species and lays down rules for their exploitation. The directive applies to the birds, their eggs, nests and habitats.
This legislation is behind the designation of Special Protection Areas (SPAs).
This directive also lists particularly vulnerable bird species on Annex I for whom protection must be given via protection of their habitats.

Wildlife Act, 1976 and Wildlife Amendment Act (2000) :- Principal national legislation which protects all bird species, their nests and eggs.

Red Data Lists:

Status of Birds in Ireland: an analysis of conservation concern (Lynas *et al.*, 2007).

This is the second assessment of birds of concern in Ireland (updating Newton *et al.,* 1999). The assessment covered all current Irish birds and several criteria were used to determine population status: Global conservation status, European conservation status, decline in population, decline in breeding range, decline in population during non-breeding season, historical decline in breeding population, breeding rarity, localised breeding and non-breeding species and international importance during breeding and non-breeding season.

Waterbird Population Assessment

Assessment of a species local population size is based on National and International importance thresholds. A site of national importance regularly holds 1% of the estimated national population of a species. A site of international importance is defined as regularly holding 20,000 waterbirds and/or regularly holding 1% of the individuals in a population of a species or subspecies. The same criteria are used to define Ramsar Sites (Ramsar Convention Bureau, 1984).

A waterbird species that occurs in numbers that correspond to 1% or more of the individuals in a national population of a species or subspecies are said to occur in 'nationally important numbers.'

Similarly, a waterbird species that occurs in numbers that correspond to 1% or more of the individuals in the worldwide population of a species or subspecies are said to occur in 'internationally important numbers.'

Current population threshold values are published in Crowe et al. (2008) and Wetlands International (2006) (national and international respectively).

Appendix 4.2

Waterbird species recorded during the waterbird counts undertaken across the survey area, 2008

Birds of Conservation Concern - Criteria: IUCN (Global conservation status), SPEC (European conservation status); BDp, BDMp (decline in population); BDr, BDMr (decline in breeding range); WDp, WDMp (decline in population during non-breeding season); HD (historical decline in breeding population); BR (breeding rarity); BL (localised breeding); WL (non-breeding species); BI (international importance during breeding season); WI (international importance during non-breeding season).

Bird Species	Listed on Birds Of Conservation Concern (Lynas *et al.,* 2007))	Listed on Annex I of EU Birds Directive (79/409/EEC)
Black-Headed Gull *Larus ridibundus*	Red-list (BDp, BDr)	
Black-tailed Godwit *Limosa limosa*	Amber-list (SPEC, WL)	
Common Gull *Larus canus*	Amber-list (SPEC, BDMr, BL)	
Common Tern *Sterna hirundo*	Amber-list (BL)	*
Cormorant *Phalacrocorax carbo*	Amber-list (BL)	
Curlew *Numenius arquata*		
Dunlin *Calidris alpina*	Amber-list (SPEC, WL)	
Golden Plover *Pluvialis apricaria*	Red-list (BDp)	*
Great Black-backed gull *Larus marinus*	Amber-list (BDMp)	
Great Crested Grebe *Podiceps cristatus*	Amber-list (WL)	
Grey Heron *Ardea cinerea*		
Grey Plover *Pluvialis squatarola*	Amber-list (WL)	
Greenshank *Tringa nebularia*	Amber-list (BR, WI)	
Herring Gull *Larus argentatus*	Red-list (BDp)	
Knot *Calidris canutus*	Red-list (WDp)	
Lapwing *Vanellus vanellus*	Red-list (BDp)	
Lesser Black-backed gull *Larus fuscus*	Amber-list (BL)	
Little Egret *Egretta garzetta*		*
Mallard *Anas platyrhynchios*		
Mediterranean Gull *Larus melanocephalus*	Amber-list (BR)	
Oystercatcher *Haematopus ostralegus*	Amber-list (WL)	
Pintail *Anas acuta*	Red-list (WDp)	
Red-breasted Merganser *Mergus serrator*		
Redshank *Tringa totanus*	Red-list (HD, SPEC, WL)	
Ringed Plover *Charadrius hiaticula*	Amber-list (WI)	
Shelduck *Tadorna tadorna*	Amber-list (WL)	
Snipe *Gallinago gallinago*	Amber-list (SPEC)	
Teal *Anas crecca*	Amber-list (BDMr)	
Turnstone *Arenartia interpres*		
Whimbrel *Numenius phaeopus*		
Wigeon *Anas penelope*	Amber-list (WL)	

Appendix 4.3

Waterbird Survey Data

Data tables show waterbird species recorded together with the time of survey, tidal time and the stage of the tide in relation to the following four tidal periods:

Tide 1: Initial tidal ebb
Tide 2: tidal ebb approaching and including low water,
Tide 3: initial tidal inflow, and
Tide 4: tidal inflow approaching high water.

(1)

26-Nov-08										
Replicates of Zones A & B	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**B**	**B**
COUNT TIME	09:15	10:15	11:15	12:15	13:15	09:45	10:45	11:45	12:45	13:45
TIDAL TIME (Low)	10:45	10:45	10:45	10:45	10:45	10:45	10:45	10:45	10:45	10:45
TIDAL PERIOD	LT-2	LT-1	LT+1	LT+2	LT+3	LT-2	LT	LT+1	LT+2	LT+3
TIDAL STAGE	2	2	3	3	3	2	2	3	3	3
Shelduck	63	61	4	12	16					
Wigeon	11	9								
Teal										2
Little Egret	1	1					1	1	1	2
Grey Heron						1				
Oystercatcher	25	12	13	13	17	6	3	5	16	16
Knot	7	7	7	1	4					
Dunlin	206	227	278	110	134		6			62
Snipe	1									
Black T Godwit	31	33	30	4	8				14	13
Curlew	6	2	2	5	6	7	4	6	11	12
Redshank	71	67	62	48	108	8	25	25	20	52
Greenshank	1					0		1	1	1
Turnstone	41	38		14	28	0				
Mediterranean Gull								3		
Black-headed Gull						1	1	2	8	19
Common Gull	1		1					2		1
Herring Gull										2
TOTAL	**465**	**457**	**397**	**207**	**321**	**23**	**40**	**45**	**71**	**182**

(2)

28-Nov-08										
Replicates of Zones A & B	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**B**	**B**
COUNT TIME	10:45	11:45	12:45	13:45	14:45	10:15	11:15	12:15	13:15	14:15
TIDAL TIME (Low)	11:52	11:52	11:52	11:52	11:52	11:52	11:52	11:52	11:52	11:52
TIDAL PERIOD	LT-2	LT-1	LT+1	LT+2	LT+3	LT-2	LT-1	LT+1	LT+2	LT+3
TIDAL STAGE	2	2	3	3	3	2	2	3	3	3
Cormorant							1			
Shelduck	19	21	12	12						
Wigeon	7		6	15	15					
Pintail						1				
Little Egret						1	1	1		
Grey Heron						2	2		1	
Oystercatcher	14	10	13	12	15	12	13	15	10	20
Knot	4	6	4	3	3					
Dunlin		526	404	579	2					
Black T Godwit	33	35	33	18	21	9	8	11	11	15
Curlew	6	3	5	4	3	4	4	7	4	12
Redshank	64	76	58	72	60	28	30	28	42	42
Greenshank				1		1	1			1
Turnstone		10								
Black-headed Gull						1	1	4	1	
Herring Gull								1		
TOTAL	**147**	**687**	**535**	**716**	**119**	**59**	**61**	**67**	**69**	**90**

(3)

10-Dec-08										
Replicates of Zones A & B	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**B**	**B**
COUNT TIME	09:35	10:35	11:35	12:35	13:35	10:05	11:05	12:05	13:05	14:05
TIDAL TIME (Low)	09:14	09:14	09:14	09:14	09:14	09:14	09:14	09:14	09:14	09:14
TIDAL PERIOD	LT+1	LT+2	LT+3	LT+4	LT+5	LT+1	LT+2	LT+2	LT+3	LT+4
TIDAL STAGE	3	3	3	4	4	3	3	3	3	4
Shelduck	63	61	63		95				1	3
Wigeon	0	8	7	12	8		21	19	18	15
Teal	6	21	19	19	0		4	10	4	7
Mallard			2		0					
Cormorant								1		
Little Egret							2	1	2	
Grey Heron						1				1
Oystercatcher	16	16	22	16	4	11	11	17	14	2
Ringed Plover	9	9	8							
Grey Plover		1								
Knot	6	6	3							
Dunlin	1300	460	106	45					36	
Snipe		4	1				1	2		
Black T Godwit	6							3	7	
Curlew	9	4	4	2		2	1	6	4	

Redshank	108	102	107	24	9	34	48	47	69	12
Greenshank	0	1	1	1	1	2	2	2	1	2
Turnstone	34	29	51	14	8			8	24	
Black-headed Gull	1	3	2	1		2	1	1		
Common Gull				1						
TOTAL	**1558**	**725**	**396**	**135**	**125**	**52**	**91**	**117**	**180**	**42**

(4)

12-Dec-08						
Replicates of Zones A & B	**A**	**A**	**A**	**B**	**B**	**B**
COUNT TIME	12:15	13:15	14:15	12:45	13:45	14:45
TIDAL TIME (Low)	11:06	11:06	11:06	11:06	11:06	11:06
TIDAL PERIOD	LT+2	LT+3	LT+4	LT+2	LT+3	LT+4
TIDAL STAGE	3	3	4	3	3	4
Shelduck	8				13	71
Oystercatcher	23	46		3	4	4
Dunlin	1144	510	6	11	498	824
Black T Godwit				2		4
Curlew	3	1				
Redshank	52	70	18	45	63	28
Greenshank	1					
Turnstone		12				
Black-headed Gull				2		
TOTAL	**1231**	**639**	**24**	**63**	**578**	**931**

Note: Count abandoned due to bad weather (rain) and poor visibility.

Appendix 4.4

Data from the Irish Wetland Bird Survey (I-WeBS) (provided by BirdWatch Ireland)

I-WeBS

Cork Harbour subsites (Rathcoursey & Ahanesk, Weir Island, Ballintubbrid, Brick Island and North Channel – Ballintubbrid) combined 2002/03 – 2006/07

Species	1% National	1% International	2002/03	2003/04	2004/05	2005/06	2006/07	Peak	Mean
Mute Swan	110	110	5	7	2	4	2	7	4
Whooper Swan	130	210	5					5	1
Canada Goose						1		1	0
Shelduck	150	3,000	902	798	589	455	311	902	611
Wigeon	820	15,000	894	1,295	883	1,184	575	1,295	966
Gadwall	20	600		2				2	0
Teal	450	5,000	446	247	493	507	177	507	374
Mallard	380	20,000	60	160	97	135	75	160	105
Pintail	20	600	73	45	20	14	1	73	31
Shoveler	25	400	3	4	13	2	4	13	5
Eider	30	12,830		1		1	1	1	1
Common Scoter	230	16,000	1					1	0
Goldeneye	95	11,500	2					2	0
Red-breasted Merganser	35	1,700	41	44	45	42	33	45	41
Great Northern Diver		50					1	1	0
Little Grebe	25	4,000	3	10	18	12	14	18	11
Great Crested Grebe	55	3,600	23	41	29	44	29	44	33
Cormorant	140	1,200	92	244	81	58	91	244	113
Little Egret		1,300	11	33	44	34	27	44	30
Grey Heron	30	2,700	9	25	34	37	25	37	26
Moorhen	20			2	2	2	1	2	1
Coot	330	17,500		9				9	2
Oystercatcher	680	10,200	330	661	348	555	245	661	428
Ringed Plover	150	730		6		8	13	13	5
Golden Plover	1,700	9,300	762	1,560	1,264	502	416	1,560	901
Grey Plover	65	2,500	7	7	1	3	6	7	5
Lapwing	2,100	20,000	553	884	586	997	694	997	743
Knot	190	4,500	80	12		60	55	80	41
Curlew Sandpiper			1		2	3	1	3	1
Dunlin	880	13,300	1,317	1,545	318	616	1,002	1,545	960
Ruff		12,500		1				1	0
Snipe		20,000	4	38		28	14	38	17
Black-tailed Godwit	140	470	408	92	394	287	148	408	266
Bar-tailed Godwit	160	1,200	21		1	20	2	21	9
Whimbrel		2,000				2	1	2	1
Curlew	550	8,500	610	391	433	347	295	610	415
Spotted Redshank		900					1	1	0
Redshank	310	3,900	851	468	497	468	456	851	548
Greenshank	20	2,300	15	25	25	20	19	25	21
Green Sandpiper			1					1	0
Common Sandpiper			2					2	0
Turnstone	120	1,500	99	71	74	61	58	99	73
Mediterranean Gull							1	1	0
Black-headed Gull		20,000		1,321	72		50	1,321	289
Common Gull		16,000		62	46			62	22
Lesser Black-backed Gull		4,500		185	242		29	242	91
Herring Gull		13,000			7		57	57	13
Great Black-backed Gull		4,800		55	30		7	55	18
Sandwich Tern							2	2	0
Kingfisher					1	2		2	1
Total wildfowl & waders			**7,631**	**8,728**	**6,293**	**6,509**	**4,793**	**8,728**	**6,791**

*** Note there has been a taxonomic change within the wildfowl, which are now headed by swans and geese.**

The counts presented in the table refer to the peak counts of species in each I-WeBS season.
Site peak and mean are calculated as the peak and mean of peak counts respectively over the seasons specified. Blank cells within columns which contain positive values for one or more species constitute zero for those species.

Weir Island

Species	1% National	1% International	2002/03	2003/04	2004/05	2005/06	2006/07	Peak	Mean
Shelduck	150	3,000	64	174	151	106	92	174	117
Wigeon	820	15,000	107	102	87	42	38	107	75
Teal	450	5,000	1	2	27	34	8	34	14
Mallard	380	20,000		2		3	2	3	1
Little Grebe	25	4,000					3	3	1
Great Crested Grebe	55	3,600			1			1	0
Cormorant	140	1,200	1		1	6	1	6	2
Little Egret		1,300	1	3	5	2	2	5	3
Grey Heron	30	2,700	1	3	1	1	1	3	1
Oystercatcher	680	10,200	70	297	156	243	153	297	184
Ringed Plover	150	730		4				4	1
Golden Plover	1,700	9,300			1,224			1,224	245
Grey Plover	65	2,500	1	1				1	0
Lapwing	2,100	20,000	2	148	32	210		210	78
Knot	190	4,500	38	12		60	6	60	23
Curlew Sandpiper					1			1	0
Dunlin	880	13,300	351	536	243	314	132	536	315
Snipe		20,000				1	2	2	1
Black-tailed Godwit	140	470	20	62	62	68	6	68	44
Curlew	550	8,500	59	36	120	73	47	120	67
Redshank	310	3,900	352	196	334	335	87	352	261
Greenshank	20	2,300	2	2	6	1	1	6	2
Common Sandpiper			1					1	0
Turnstone	120	1,500	69	30	22	27	43	69	38
Total wildfowl & waders			**1,140**	**1,610**	**2,473**	**1,526**	**624**	**2,473**	**1,475**

Brick Island

Species	1% National	1% International	2002/03	2003/04	2004/05	2005/06	2006/07	Peak	Mean
Mute Swan	110	110	5					5	1
Shelduck	150	3,000	1	2	3	37	81	81	25
Wigeon	820	15,000	20	36	25	6	18	36	21
Teal	450	5,000	12	15	12	42	4	42	17
Mallard	380	20,000	5		2	18		18	5
Red-breasted Merganser	35	1,700	7	2		2	2	7	3
Great Crested Grebe	55	3,600		1		1	1	1	1
Cormorant	140	1,200	1	2	1	1		2	1
Little Egret		1,300	2	1	1	1	2	2	1
Grey Heron	30	2,700	1		1			1	0
Oystercatcher	680	10,200	21	11	7	9	14	21	12
Golden Plover	1,700	9,300	700					700	140
Lapwing	2,100	20,000		103	24	36	70	103	47
Dunlin	880	13,300	40	590		70	367	590	213
Snipe		20,000		2		16		16	4
Black-tailed Godwit	140	470	106	36	14	8	87	106	50
Curlew	550	8,500	20	24	10	9	6	24	14
Redshank	310	3,900	47	51	64	27	106	106	59
Greenshank	20	2,300	2	5	3	2	6	6	4
Green Sandpiper			1					1	0
Turnstone	120	1,500	35		38	36		38	22
Kingfisher						1		1	0
Total wildfowl & waders			**1,026**	**881**	**205**	**322**	**764**	**1,026**	**640**

* Note there has been a taxonomic change within the wildfowl, which are now headed by swans and geese.

The counts presented in the table refer to the peak counts of species in each I-WeBS season.
Site peak and mean are calculated as the peak and mean of peak counts respectively over the seasons specified. Blank cells within columns which contain positive values for one or more species constitute zero for those species.

North Channel - Ballintubbrid

Species	1% National	1% International	2002/03	2003/04	2004/05	2005/06	2006/07	Mean	Peak
Mute Swan	110	110		7		2		2	7
Whooper Swan	130	210	5					1	5
Shelduck	150	3,000	689	514	258	264	311	407	689
Wigeon	820	15,000	466	403	226	338	210	329	466
Gadwall	20	600		2				0	2
Teal	450	5,000	248	110	193	196	87	167	248
Mallard	380	20,000	15	19	18	9	43	21	43
Pintail	20	600	73	45	20	14	1	31	73
Shoveler	25	400		2	2			1	2
Eider	30	12,830		1		1	1	1	1
Common Scoter	230	16,000	1					0	1
Red-breasted Merganser	35	1,700	27	38	45	32	33	35	45
Great Northern Diver		50					1	0	1
Little Grebe	25	4,000	3	2	6	4	4	4	6
Great Crested Grebe	55	3,600	3	16	24	37	29	22	37
Cormorant	140	1,200	35	24	22	15	31	25	35
Little Egret		1,300	7	19	20	17	27	18	27
Grey Heron	30	2,700	4	12	14	21	25	15	25
Coot	330	17,500		9				2	9
Oystercatcher	680	10,200	222	343	143	225	161	219	343
Ringed Plover	150	730		6				1	6
Golden Plover	1,700	9,300		3			2	1	3
Grey Plover	65	2,500		4		3	2	2	4
Lapwing	2,100	20,000	80	46	170	250	26	114	250
Knot	190	4,500	42				55	19	55
Dunlin	880	13,300	930	121	50	200	45	269	930
Snipe		20,000	1	2		2		1	2
Black-tailed Godwit	140	470	305	15	50	50	148	114	305
Bar-tailed Godwit	160	1,200	21			8		6	21
Whimbrel		2,000				1	1	0	1
Curlew	550	8,500	522	260	207	134	295	284	522
Greenshank	20	2,300	3	15	8	8	16	10	16
Redshank	310	3,900	620	270	216	260	331	339	620
Turnstone	120	1,500	20	41	32	30	30	31	41
Mediterranean Gull							1	0	1
Black-headed Gull		20,000		1,321	72		50	289	1,321
Common Gull		16,000		62	46			22	62
Lesser Black-backed Gull		4,500		185	242		29	91	242
Herring Gull		13,000			7		57	13	57
Great Black-backed Gull		4,800		55	30		7	18	55
Sandwich Tern							2	0	2
Total waterbirds			**4,342**	**3,972**	**2,121**	**2,121**	**2,061**	**2,923**	**4,342**

Cork Harbour

Species	1% National	1% International	2001/02	2002/03	2003/04	2004/05	2005/06	Peak	Mean
Kittiwake						1		1	0
Red-throated Diver	20	3,000					1	1	0
Great Northern Diver		50	1	1	1			1	1
Little Grebe	25	4,000	59	60	88	80	69	88	74
Great Crested Grebe	55	3,600	287	240	132	105	137	287	154
Red-necked Grebe								0	0
Slavonian Grebe		55			3	1	2	3	2
Black-necked Grebe			2					2	0
Cormorant	140	1,200	392	326	357	370	308	392	340
Shag						2		2	1
Grey Heron	30	2,700	57	97	68	135	76	135	94
Little Egret		1,300	39	61	83	166	126	166	109
Mute Swan	110	110	15	42	56	71	54	71	56
Bewick's Swan	20	200			2			2	1
Whooper Swan	130	210	14	12	15	7		15	9
Greylag Goose	50	870	4	4	1	1	3	4	2
Canada Goose			8	2	21	23	11	23	14
Light-bellied Brent Goose	220	260		6	12	16	26	26	15
Feral/hybrid Goose						2		2	1
Shelduck	150	3,000	1,108	1,903	1,946	1,391	1,350	1,946	1,648
Wigeon	820	15,000	1,519	1,931	2,926	2,043	2,332	2,926	2,308
Gadwall	20	600	8	67	17	13	13	67	28
Teal	450	5,000	1,079	1,492	1,611	1,169	1,302	1,611	1,394
Green-winged Teal			1	1				1	0
Mallard	380	20,000	362	489	539	628	406	628	516
Pintail	20	600	74	73	46	20	14	74	38
Shoveler	25	400	48	103	33	24	45	103	51
Pochard	380	3,500	21	27	18	7	7	27	15
Ring-necked Duck				1				1	0
Tufted Duck	370	12,000	36	29	33	14	14	36	23
Scaup	45	3,100					2	2	1
Eider	30	12,830			1		15	15	4
Long-tailed Duck		20,000		2				2	1
Common Scoter	230	16,000		1	1	3	7	7	3
Goldeneye	95	11,500	28	11	14	7	10	28	11
Red-breasted Merganser	35	1,700	77	95	88	85	80	95	87
Coot	330	17,500	13	26	31	23	16	31	24
Moorhen	20		19	24	46	24	33	46	32
Water Rail			1	1	1	2	2	2	2
Oystercatcher	680	10,200	1,061	1,570	2,021	1,857	2,076	2,076	1,881
Ringed Plover	150	730	66	28	68	25	67	68	47
Golden Plover	1,700	9,300	6,888	4,262	5,102	6,200	3,002	6,888	4,642
Grey Plover	65	2,500	6	108	37	4	24	108	43
Lapwing	2,100	20,000	2,816	4,176	4,864	4,133	4,096	4,864	4,317
Knot	190	4,500	79	306	114	85	117	306	156
Sanderling	65	1,200		135	350		33	350	130
Curlew Sandpiper			2	1		3	4	4	2
Dunlin	880	13,300	5,155	3,979	4,785	4,325	3,874	5,155	4,241
Ruff		12,500		1	1		1	1	1
Snipe		20,000	20	20	54	14	49	54	34
Long-billed Dowitcher			1	1				1	0
Black-tailed Godwit	140	470	2,128	3,162	1,518	2,937	3,337	3,337	2,739
Bar-tailed Godwit	160	1,200	419	477	405	298	218	477	350
Whimbrel		2,000	1	1	3	1	4	4	2
Curlew	550	8,500	1,329	1,817	1,083	2,317	1,809	2,317	1,757
Spotted Redshank		900	1	2	1	2	1	2	2

The counts presented in the table refer to the peak counts of species in each I-WeBS season.
Site peak and mean are calculated as the peak and mean of peak counts respectively over the seasons specified. Blank cells within columns which contain positive values for one or more species constitute zero for those species.

Redshank	310	3,900	1,138	2,170	1,591	2,295	1,543	2,295	1,900
Greenshank	20	2,300	25	60	47	83	68	83	65
Green Sandpiper			1	1	1	1	1	1	1
Common Sandpiper			2	2	2	2	2	2	2
Turnstone	120	1,500	66	145	131	161	136	161	143
Unidentified gull			2,123					2,123	0
Mediterranean Gull			2	12	11	13	15	15	13
Sabine's Gull					1			1	0
Black-headed Gull		20,000	1,180	1,811	2,954	2,170	2,627	2,954	2,391
Ring-billed Gull			1		1	1		1	1
Common Gull		16,000	1,725	459	200	290	188	1,725	284
Lesser Black-backed Gull		4,500	106	63	254	496	31	496	211
Herring Gull		13,000	16	37	32	36	40	40	36
Iceland Gull								0	0
Great Black-backed Gull		4,800	76	110	150	385	157	385	201
Unidentified Tern					3			3	1
Sandwich Tern			34	5		2	225	225	58
Common Tern				2	1		1	2	1
Kingfisher			2	1	3	3	3	3	3
Sum of species peaks			31,741	32,051	33,978	34,572	30,210	34,572	32,703

The counts presented in the table refer to the peak counts of species in each I-WeBS season.
Site peak and mean are calculated as the peak and mean of peak counts respectively over the seasons specified. Blank cells within columns which contain positive values for one or more species constitute zero for those species.

5.0 REVIEW OF SHELLFISH DATA

5.1 Background to Shellfish Monitoring

In accordance with several EU Directives, Ireland carries out monitoring programmes including:-

- Contaminants in shellfish and shellfish waters – monitoring is undertaken annually by the Marine Institute in part fulfilment of EU legislation EU Directive 91/492/EEC EEC that controls the production and public sale of live bivalve molluscs, and EU Directive (79/923/EEC) that is concerned with the quality of shellfish waters. Contaminants include trace metals, Polychlorinated biphenyls (PCB's) and Organochlorines (OCP's).

- National Marine Biotoxin Monitoring Programme (DCMNR/FSAI) – under Council Directive 853/2004, Ireland is required to monitor shellfish harvesting areas for the presence of toxins produced by some species of phytoplankton. The Programme covers the following toxins, Diarrhetic Shellfish Poisoning (DSP), Azaspiracid poisoning (AZP), Paralytic Shellfish Poisoning (PSP) and Amnesic Shellfish Poisoning (ASP). Other toxins are also tested for on an ongoing basis.

- Microbiological quality of shellfish waters - the Sea Fisheries Protection Authority (SFPA) implements EU Directives on the quality of shellfish waters. European Regulations Nos. 852/2004, 853/2004 and 854/2004 have surpassed EU Directive 91/492/EEC in laying down the conditions for the production and public sale of live bivalve molluscs. Under the classification, shellfish harvesting areas are classified according to the shellfish microbiological standards: Class A (no restrictions; can be collected for direct human consumption); Class B (depurated, heat treated or relayed to meet Class A standards), Class C (relay in a clean area for at least 2 months prior to sale), Class D (harvesting prohibited).

5.2 Review of data for Cork Harbour North Channel

5.2.1 Contaminants in shellfish and shellfish waters

Until relatively recently, data for trace metal concentrations in shellfish were published annually as a Marine Institute Publication '*Trace metal concentrations in shellfish from Irish waters,* Marine Environment and Health Series.' The most recent publication was in 2006 (Boyle *et al.,* 2006) and this data was reviewed in Limosa Environmental (2007). In order to complete the 2008 review, data was obtained directly from the Marine Institute under Licence Agreement Number 2008/216 dated 14/10/2008. This data is shown in Appendix 5.1.

The level of contaminants within shellfish tissue are a good indicator of levels present within the water column, therefore providing valuable information as to the quality of the shellfish and the waters in which they were grown (Boyle *et al.,* 2006). While metals such as zinc, copper, iron, nickel and chromium are natural components of biological tissues, others such as mercury, lead and arsenic have no known biological role. Any metal however, if present at a sufficiently high level can pose a toxicological threat (Marine Institute, 1999).

The data received for the North Channel (2007, Appendix 5.1) was compared with the available reference (guidance) limits presented within Table 5.1. All data were within the accepted guidance limits.

Contaminant	Values and Units (wet weight)
Cadmium	1.0 mg kg^{-1}
Copper	20 mg kg^{-1} (60 mg kg^{-1} for oysters)
Lead	1.5 mg kg^{-1}
Mercury	0.5 mg kg^{-1}
p,p' DDT & metabolites	500 µg kg^{-1}
HCB	50 µg kg^{-1}
A and β HCH	50 µg kg^{-1}
Lindane (gamma HCH)	100 µg kg^{-1}
PCB 28	80 µg kg^{-1}
PCB 52	80 µg kg^{-1}
PCB 101	80 µg kg^{-1}
PCB 138	100 µg kg^{-1}
PCP 153	100 µg kg^{-1}
PCB 180	80 µg kg^{-1}

Table 5.1 Synopsis of the strictest guidance and standard values applied by various OSPAR countries for contaminants in shellfish together with European legislation levels (Regulation 466/2001/EEC as amended by Commission regulation 221/2002/EEC) for mercury, cadmium and lead (Data source: Glynn et *al.,* 2004 and Boyle *et al.,* 2006).

Oysters are known to accumulate high levels of zinc in their tissues under natural conditions. Data in Appendix 5.1 shows significantly greater levels of zinc in oysters (*C. gigas*) than in Blue Mussels (*M. edulis*). There is no set European limits for zinc levels within shellfish tissues, but sample data for mussels in Appendix 5.1 is within the OSPAR background range of 11.6 – 30 mg/kg and the levels recorded are not considered elevated.

In the absence of guidance limits, the remaining data in Appendix 5.1 were compared against pervious reviews of contaminants in shellfish (e.g. Marine Institute, 1999) and no data point is considered to be abnormally elevated.

5.2.2 Biotoxins

Under the National Marine Biotoxin Monitoring Programme (DCMNR/FSAI) Ireland is required to monitor shellfish harvesting areas for the presence of toxins produced by some species of phytoplankton.

The FSAI website shows the status of shellfish production areas based on the most recent data provided by the Marine Institute. A review of this data on 10/11/2008 showed an 'open' status for the Pacific Oyster aquaculture facility in the North Channel.
(http://www.fsai.ie/sfma/eastCork.asp?species=C.gigas&county=eastCork.asp).

5.2.3 Microbiological quality of shellfish waters – Shellfish Production Areas

There is currently a Shellfish Production Area within the North Channel – Area CK-CH-NC, licensed to produce Pacific Oyster (*Crassostrea gigas*), Native Oyster (*Ostrea edulis*) and Blue Mussels (*Mytilus edulis*) (source www.fsal.ie).

The most up-to-date Bivalve Mollusc Production Area Listing for Ireland was obtained from the Sea Fisheries Protection Authority (www.sfpa.ie). Dated 6th November 2008, the classification is shown below (Table 5.2)

Table 5.2 Classified Bivalve Mollusc Production Areas in Ireland (6th November 2008) (www.sfpa.ie)

Cork Harbour	Between 8°16.4' W and 8° 15.6' W.	North Channel West	Oysters	Class B
	Between 8°14.6'W and 8°13.2'W.	North Channel East	Oysters	Class B

Appendix 5.1

Shellfish Data – Contaminants in shellfish – data supplied by the Marine Institute October 2008.

Sample Site	Cork Harbour - N & E Channels	Cork Harbour - N & E Channels	Cork Harbour - N & E Channels
M.I. Reference No.	ENV/07/0002	ENV/07/0003	ENV/07/070
Sampling Date	05/01/07	05/01/07	19/09/07
Latitude	51º 52.872	51º 52.872	51º 52.860
Longitude	8º 15.573	8º 15.573	8º 15.528
Species sampled	*C. gigas*	*M. edulis*	*M. edulis*
Number individuals	25	50	50
Method of cultivation	Bed	Trestle	bed
Water Parameters			
Temperature (°C)	9.74	9.74	17.29
Salinity	8.17	8.17	30.95
pH	7.98	7.98	7.99
Suspended Solids (mg L^{-1})	93.3	93.3	
Shellfish			
Shell length range (mm)	83.0 – 110	42.5 – 58	40.0-51.5
Shell mean length (mm)	100	50	44.2
Shell length std dev (mm)	6.20	3.60	3.10
Meat weight (%)	9.6	28.9	25.0
Shell weight (%)	90.4	71.1	75.0
Meat water content (%)	80.8	79.1	74.1
Metals mg kg^{-1} (ppm) wet wt.			
Cadmium	0.16	0.15	0.17
Chromium	0.1	0.21	0.18
Copper	10.2	1.52	1.66
Lead	0.4	0.51	
Mercury	0.04	0.02	0.03
Zinc	218	16.9	17.5
Nickel	<0.13	0.38	
Silver	0.44	0.01	0.02
PCB's mg kg^{-1} (ppb) wet wt.			
CB Congener 28			0.08
CB Congener 52			0.11
CB Congener 101			0.31
CB Congener 105			
CB Congener 118			0.28
CB Congener 138			0.64
CB Congener 153			0.74
CB Congener 156			
CB Congener 180			0.06
DDT-pp'			0.03

DDE-pp'	0.65
DDT-op'	<0.01
DDE-op'	0.02
TDE-op'	0.11
TDE-pp'	0.15
Dieldrin	0.56
Hexachlorobenzene	0.01
alpha-HCH	0.01
beta-HCH	<0.01
gamma-HCH	0.02
delta-HCH	<0.01
trans-Nonachlordane	0.03
trans-Chlordane	0.01
cis-Chlordane	0.02
Endrin	0.12
Aldrin	<0.05
Oxychlordane	<0.01
Endosulfan sulfate	<0.10
Mirex	<0.01
alpha-endosulfan	<0.05
beta-endosulfan	<2.00
trans-heptachloroepoxide	<0.05
Heptachlor	<0.05
Octachlorostyrene	<0.01
cis-Heptachloroepoxide	0.02
Palar 26	<0.03
Palar 50	<0.05
Palar 62	<0.10
PAHs mg kg^{-1} (ppb) wet wt.	
Fluoranthene	
Lipid Smedes (%)	1.77

6.0 REVIEW OF EPA WATER QUALITY DATA

6.1 Overview

This final section of the ecological monitoring report reviews data from the Environmental Protection Agency (EPA) Estuarine and Coastal Water Quality Monitoring programme. This monitoring programme is carried out in conjunction with local authorities and the Marine Institute, a major objective being to assess the eutrophic status of the coastal waters.

There are five EPA sampling stations in relatively close proximity to East Cork Landfill (Table 6.1).

Table 6.1 EPA sampling stations in closest proximity to East Cork Landfill:

Station Number	Name	Grid Reference	Location
LE410	Belvelly Bridge	W 179 708	Approx 2.8 km west of Rossmore Peninsula
LE420	North Channel, Weir Island Pylons	W 814 703	Approx 700m west of Rossmore Peninsula
LE430	North Channel, Brick Island	W 833 697	Approx 250 east of Rossmore Peninsula
LE440	North Channel 'Red Shed'	W 845 697	Approx 1.7km east of Rossmore peninsula
LE450	North Channel Bagwells Hill	W 860 699	Approx 3.2 km east of Rossmore Peninsula

7.2 Review of EPA water quality data for Cork Harbour North Channel

The most recently available water quality data for the North Channel covers the period 2003 – 2007 (data kindly provided by Shane O'Boyle, Environmental Protection Agency in November 2008). Summary data for the North Channel is shown in Table 6.2 and the full data set is given in Table 7.3.

Data were assessed in relation to available guidance limits (e.g. McGarrigle *et al*., 2002; Toner *et al.,* 2005; Quality of Shellfish Waters Regulations, 1994).

Table 6.2 Summary water quality data for Cork Harbour North Channel 2003 – 2007 (data kindly provided by the EPA).

	DO %	BOD	TON	NH_3	Free NH_3	PO_4	Chlorophyll *a*
Minimum	83.6	1.0	0.01	0.009	0.0002	10	0.99
Maximum	148	4.0	39.90	0.257	0.0155	64	33.70
Median	99	2.1	0.22	0.038	0.0016	10	5.90

- **Dissolved Oxygen (DO)** - the accepted range for intermediate (brackish) waters is between 70 and 130 % saturation (Toner *et al.,* 2005). Two water quality records have exceeded the upper limit during the past five years hence the maximum value (Table 6.2) exceeds the upper limit. However, the most recent records from 2007 show DO levels within the accepted range at all five sampling stations.
- **Total Ammonia (NH_3) –** refers to the sum of ammonia (NH_3) and the ionised form (NH_4^+). Low-level ammonia nitrogen may be present in water naturally as a result of the biological decay of plant and animal matter. Anthropogenic sources to seawater include sewage and industrial effluents and fertilizer run-off. Background levels in seawater may range between 0.001 – 0.05 mg/l. Levels recorded over the past five years range from 0.009 - 0.257 mg/l (Table 6.2). All levels over 0.05mg/l are highlighted in Table 7.3.
- The unionized form of ammonia (NH_3) '**free ammonia'** is extremely toxic to fish, concentrations in water increase with rising temperature and pH levels and decrease with rising salinities. All data points in Table 6.3 show levels below 0.02 mg/l and considered acceptable.
- **Dissolved inorganic nitrogen (DIN) (mg/l N^2)** - elevated levels are highlighted in Table 6.3; (elevated readings are those > 1.4 mg/l N^2 at median salinity 17psu).
- **Phosphorous** - the recommended level of total phosphorus in estuaries and coastal ecosystems to avoid algal blooms is 0.01 to .1 mg/l (US EPA) (equivalent to 10 – 100 µg/l P). All levels in table 6.3 are within the acceptable range.

- **Chlorophyll *a*** - within Intermediate waters, levels that exceed 15 mg/m^3 (median) or 30 mg/m^3 (90 percentile) are deemed high (Toner *et al.,* 2005). The Marine Institute (1999) identifies values of 10-25 mg/m^3 as 'medium' and >25 mg/m^3 as high. Levels above 25 mg/m^3 are highlighted in Table 6.2.
- **pH** - the pH of most natural waters lies between 6.0 and 8.5 (Chapman, 1996) and extreme values in ph are deleterious to the aquatic system and may lead to knock-on effects on fauna e.g. fish. Over the past five years, pH readings at the five sampling stations range between pH 7.98 and pH 8.33; all within acceptable levels.

Discussion & Conclusions

Recent water quality data for the North Channel shows several elevated readings in recent years (e.g. DIN, $NH_{3.)}$ Total Ammonia appears to be the water quality parameter that is exceeded the most and at more than one station (Stations 420, 430 and 430).

Anthropogenic sources of NH_3 to seawater include sewage, industrial effluents and fertilizer run-off and it is not possible to link elevated levels within the North Channel to landfill activity as there are so many other confounding variables (i.e. other possible pollution sources).

Previously classified as 'Eutrophic' by the EPA, the North Channel has retained an improved classification of 'intermediate' across EPA assessment periods 1999 – 2003 and 2002 – 2006.

Table 7.3 Water quality data for Cork Harbour North Channel 2003 – 2007 (data kindly provided by the EPA). Recent (2007) data is shown in blue font, levels that exceed accepted guidelines are highlighted in yellow.

Station No	Survey Date	Salinity S ‰	Temp S °C	pH	DO S % Sat	B.O.D. mg/l O2	TON mg/l N	NH3 mg/l N	Free NH3 mg/l N	DIN mg/l N	PO4 µg/l P	TON:NH3	DIN:PO4 µMol	Chlorophyll a mg/m
LE420	27/02/07	24.48	9.29	8.09	92.8	1.5	1.4	0.064	0.001649	1.464	49	848.98	0.029878	0.99
LE420	27/02/07	25.47	9.05	8.09	91.5	1.5	1.4	0.064	0.0016188	1.464	49	864.8522	0.029878	0.99
LE430	27/02/07	24.3	9.25	8.1	92.7		1.3	0.11	0.0028899	1.41	36	449.8353	0.039167	0.99
LE430	27/02/07	24.3	9.25	8.1	92.7		1.3	0.11	0.0028899	1.41	36	449.8353	0.039167	0.99
LE450	27/02/07	26.3	9.27	8.11	92.3		1.08	0.134	0.0036062	1.214	54	299.4825	0.022481	0.99
LE450	27/02/07	29.59	9.06	8.11	93.3		1.08	0.134	0.0035483	1.214	54	304.3713	0.022481	0.99
LE420	19/06/2003	27.8	17.8	8.1	93.0	2.9	0.516	0.016	0.0008	0.532	15	32.3	78.4	6.1
LE420	19/06/2003	27.9	17.8	8.1	92.0	2.9	0.516	0.016	0.0008	0.532	15	32.3	78.4	6.1
LE420	31/07/2003	30.2	17.2	8.2	96.3		0.010	0.010	0.0006	0.01998	13	1.0	3.4	26.1
LE420	31/07/2003	30.8	17.14	8.2	104.7		0.010	0.010	0.0006	0.01998	13	1.0	3.4	26.1
LE420	06/07/2004	EF	EF	8.1	EF	1.7	0.102	0.009	0.0003917	0.111	9.99	260.3914	0.011111	
LE420	06/07/2004	EF	EF	8.09	EF		0.102	0.026	0.0011068	0.128	11	92.15975	0.011636	
LE420	02/06/2005	29.83	15.67	8.1	95.8	2.1	6.83	0.017	0.0006039	6.847	51	11310.38	0.134255	5.9
LE420	12/07/2005	32.6	22	8.28	148	3.4	5.3	0.049	0.0008316	5.349	21	6372.985	0.254714	13.5
LE420	12/07/2005	32.6	19.6		126.5		0.633	0.055	0.0030531	0.688	9.99	207.3326	0.068869	
LE420	23-May-06	28.29	12.45	7.93	91.7	1.4	0.49	0.085	0.0019428	0.575	9.9	252.2083	0.058081	5.8
LE420	23-May-06	28.36	12.4		91.6		0.49	0.085	0.0019428	0.575	9.9	252.2083	0.058081	5.8
LE420	22-Jun-06	32.12	15.57	8.15	92.7	3	0.145	0.082	0.003865	0.227	15	37.51634	0.015133	7.6
LE420	22-Jun-06	32.12	15.65		91.6		0.145	0.082	0.003865	0.227	15	37.51634	0.015133	7.6
LE420	20-Jul-06	33.24	20.18	8.18	105.2	2	39.9	0.176	0.0122717	40.076	9.9	3251.373	4.048081	11.9
LE420	20-Jul-06	33.23	20.02		102.8		39.9	0.176	0.0122717	40.076	9.9	3251.373	4.048081	11.9
LE420	12-Jun-07	32.62	19.44	8.17	83.6	1.6	0.088	0.069	0.0044727	0.157	27	19.67492	0.005815	
LE420	10-Jul-07	30.5	14.95	8.31	110.9	3.1	0.06	0.0199	0.001275	0.0799	9.9	47.0601	0.008071	4.8
LE420	10-Jul-07	30.38	14.92	8.31	112.9	3.1	0.06	0.0199	0.0012722	0.0799	9.9	47.16147	0.008071	4.8
LE420	21-Aug-07	30.44	15.4	8.19	102.7	4	0.206	0.045	0.0022887	0.251	9.9	90.00742	0.025354	8.8
LE420	21-Aug-07	30.45	15.4	8.19	102.1	4	0.206	0.045	0.0022887	0.251	9.9	90.00742	0.025354	8.8
LE430	19/06/2003	28.8	17.4	8.1	90.0	2.5	0.519	0.011	0.0005	0.53		47.2		5.6
LE430	19/06/2003	28.8	17.4	8.1	90.0	2.5	0.519	0.011	0.0005	0.53		47.2		5.6

LE430	06/07/2004	EF	EF	8.1	EF		0.105	0.011	0.0004788	0.116	9.99	219.3136	0.011612	
LE430	02/06/2005	30.75	14.89	8.08	95		2.31	0.041	0.0013741	2.351	19	1681.15	0.123737	5.4
LE430	12/07/2005	32.6	20.3	8.31	134.5		1.49	0.094	0.0042954	1.584	9.99	346.8802	0.158559	20.6
LE430	23-May-06	29.21	12.08	7.99	92.8		0.445	0.085	0.0021632	0.53	9.9	205.7142	0.053535	5.3
LE430	23-May-06	29.57	11.85		91.7		0.445	0.085	0.0021632	0.53	9.9	205.7142	0.053535	5.3
LE430	22-Jun-06	31.96	15.71	8.14	92.7		0.163	0.059	0.0027477	0.222	9.9	59.32145	0.022424	11.5
LE430	22-Jun-06	32.35	15.29		88.7		0.163	0.059	0.0027477	0.222	9.9	59.32145	0.022424	11.5
LE430	20-Jul-06	33.5	19.31	8.17	102.5		38.2	0.079	0.0050748	38.279	9.9	7527.337	3.866566	12.4
LE430	20-Jul-06	33.48	19.17		102.5		38.2	0.079	0.0050748	38.279	9.9	7527.337	3.866566	12.4
LE430	12-Jun-07	33	18.58	8.2	98.9		0.097	0.02	0.0013035	0.117	13	74.41331	0.009	
LE430	10-Jul-07	30.63	14.91	8.33	121		0.11	0.0199	0.0013279	0.1299	9.9	82.83538	0.013121	3.7
LE430	10-Jul-07	31.19	14.69	8.33	118.2		0.11	0.0199	0.0013072	0.1299	9.9	84.1515	0.013121	3.7
LE430	21-Aug-07	30.23	15.09	8.2	108.1		0.394	0.066	0.0033555	0.46	9.9	117.4195	0.046465	10.3
LE430	21-Aug-07	30.84	15.28	8.2	106.1		0.394	0.066	0.003402	0.46	9.9	115.8154	0.046465	10.3
LE440	19/06/2003	29.2	17.1	8.1	91.0		0.550	0.017	0.0007	0.567		32.4		10.2
LE440	19/06/2003	29.1	17.1		92.0									5.4
LE440	31/07/2003	31.3	17.0	8.3	108.5		0.010	0.010	0.0007	0.01998	10	1.0	4.4	30.5
LE440	31/07/2003	31.3	16.99	8.3	107.3		0.010	0.010	0.0007	0.01998	10	1.0	4.4	30.5
LE440	06/07/2004	EF	EF	8.1	EF	1.3	0.1	0.019	0.000827	0.119	9.99	120.9248	0.011912	
LE440	02/06/2005	30.98	14.68	8.08	95.6	1.6	2.4	0.025	0.0007681	2.425	18	3124.662	0.134722	5.3
LE440	12/07/2005	32.7	19.7	8.29	142	3.4	0.087	0.039	0.003079	0.126	9.99	28.25614	0.012613	15.6
LE440	12/07/2005	32.7					0.068	0.047	0.0034849	0.115	9.99	19.51264	0.011512	
LE440	23-May-06	30.35	11.65	7.98	91.7	0.999	0.37	0.084	0.0020231	0.454	10	182.8911	0.0454	4.6
LE440	23-May-06	30.38	11.57		91.8		0.37	0.084	0.0020231	0.454	10	182.8911	0.0454	4.6
LE440	22-Jun-06	32.97	14.85	8.14	94.4	2.8	0.133	0.064	0.0027999	0.197	9.9	47.50178	0.019899	11.6
LE440	22-Jun-06	32.96	14.8		93.9		0.133	0.064	0.0027999	0.197	9.9	47.50178	0.019899	11.6
LE440	20-Jul-06	33.75	18.76	8.15	100.7		0.015	0.075	0.004438	0.09	9.9	3.379929	0.009091	8.3
LE440	20-Jul-06	33.79	18.56		101		0.015	0.075	0.004438	0.09	9.9	3.379929	0.009091	8.3
LE440	12-Jun-07	33.3	17.89	8.21	102.7		0.056	0.0199	0.001263	0.0759	10	44.33804	0.00759	
LE440	10-Jul-07	31.83	14.49	8.25	116.4	1.7	0.11	0.0199	0.0010814	0.1299	9.9	101.7153	0.013121	6.6
LE440	10-Jul-07	31.96	14.34	8.25	116.2	1.7	0.11	0.0199	0.0010697	0.1299	9.9	102.8291	0.013121	6.6
LE440	21-Aug-07	30.85	14.98	8.15	106.7		0.355	0.0199	0.0008986	0.3749	9.9	395.058	0.037869	6
LE440	21-Aug-07	31.35	15.16	8.15	98.8		0.355	0.0199	0.0009105	0.3749	9.9	389.9141	0.037869	6

LE450	19/06/2003	29.9	16.7	8.0	91.0		0.525	0.023	0.0009	0.548		22.8		5.9
LE450	19/06/2003	30.2	16.2		89.0									5.5
LE450	31/07/2003	31.8	16.6	8.2	107.4		0.010	0.010	0.0006	0.01998	10	1.0	4.4	27.3
LE450	31/07/2003	31.6	16.7	8.3	110.1		0.010	0.010	0.0007	0.01998	10	1.0	4.4	27.5
LE450	06/07/2004	EF	EF	8.08	EF		0.131	0.024	0.0009992	0.155	9.99	131.1076	0.015516	
LE450	02/06/2005	31.99	13.81	8.07	96.8		1.71	0.25	0.004777	1.96	20	357.963	0.098	3.2
LE450	02/06/2005	31.19	14.58	8.08	94.6		2.58	0.009	0.0002429	2.589	18	10620.58	0.143833	4.6
LE450	12/07/2005	33.4	18.5	8.2	123.5	2.9	0.009	0.031	0.0020986	0.04	9.99	4.28854	0.004004	4.1
LE450	12/07/2005	32.9	19.5	8.3	141	3.3								12.5
LE450	23-May-06	29.74	11.6	7.98	89.4		0.387	0.085	0.0020394	0.472	9.9	189.763	0.047677	2.2
LE450	23-May-06	29.77	11.59		89.5		0.387	0.085	0.0020394	0.472	9.9	189.763	0.047677	2.2
LE450	22-Jun-06	32.95	14.85	8.15	94.6		0.124	0.041	0.0018339	0.165	9.9	67.61459	0.016667	11.2
LE450	22-Jun-06	33.2	14.56		96		0.124	0.041	0.0018339	0.165	9.9	67.61459	0.016667	11.2
LE450	20-Jul-06	33.71	18.69	8.16	100.3	1.8	25.5	0.257	0.0154679	25.757	9.9	1648.573	2.601717	8.8
LE450	20-Jul-06	33.88	18.352		102.3		25.5	0.257	0.0154679	25.757	9.9	1648.573	2.601717	8.8
LE450	12-Jun-07	33.33	17.87	8.21	104.4		0.05	0.0199	0.0012612	0.0699	9.9	39.64325	0.007061	
LE450	10-Jul-07	32.15	14.22	8.23	116.9	2.1	0.67	0.0199	0.0010147	0.6899	9.9	660.281	0.069687	6.9
LE450	10-Jul-07	32.64	13.79	8.23	119.1	2.1	0.67	0.0199	0.0009833	0.6899	9.9	681.3519	0.069687	6.9
LE450	21-Aug-07	31.4	15.07	8.1	102.2	2.9	0.257	0.0199	0.0008094	0.2769	9.9	317.5023	0.02797	4.6
LE450	21-Aug-07	32.83	14.72	8.1	98.5	2.9	0.257	0.0199	0.000789	0.2769	9.9	325.7453	0.02797	4.6

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Appendix H

Monitoring of Flare Flue Gas Emissions June & December 2008

Flare Emissions Report
Rossmore Landfill
(Cork County Council)
DOCUMENT CONTROL SHEET

Client	Cork County Council					
Project Title	Monitoring of Flare Emissions at Rossmore Landfill					
Document Title	Emissions Monitoring 2008 – Biannual Monitoring Round 1					
Document No.	MCE0541Rp001					
This Document Comprises	DCS	TOC	Text	List of Tables	List of Figures	No. of Appendices
	1	1	6	1	-	1

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D01	Draft	R. Daly	A. Ryan	-	Innishmore, Cork	12/06/08

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APPENDIX

1 INTRODUCTION

Cork County Council commissioned RPS Group under the conditions of Fee Proposal No. MCE0541Fp001 to monitor emissions to atmosphere from an AFS flare unit at Rossmore Landfill, Carrigtohill, Co. Cork.

The flare system is used to burn off landfill gas emitted from the decaying landfill waste and was sampled for emissions of Nitrogen Oxides, Carbon Monoxide, Sulphur Dioxide, Hydrocarbons, Particulate Matter and Inorganic Acids (hydrochloric and hydrofluoric acid).

This report presents the findings of the monitoring survey, which was conducted in compliance with EPA Waste Licence W0022-01.

2 MONITORING

Suitably qualified air quality personnel from RPS Group conducted the monitoring on the flare unit on July 3rd, 2008. The sampling and analytical methodologies employed are outlined below.

Monitoring of the Rossmore landfill gas flare emissions to atmosphere was the first biannual test of 2008. Monitoring of the following parameters was carried out - Flue Gas, Total Hyrdocarbons, Hydrochloric and Hydrofluoric Acid, and Particulate Matter.

2.1 FLUE GAS ANALYSIS

Flue gas emissions were measured using a Testo 350 flue gas analyser. This is a specialised flue gas analysis system fully equipped with electrochemical sensors. The Flue Gas Analyser measures the following parameters:

- Temperature
- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Sulphur Dioxide (SO_2)

Five sampling rounds were conducted over a 30-minute period. All the above are to be expressed at reference conditions of 273K, 101.3 kPa, dry gas and the correct oxygen reference for the combustion fuel.

Results will be referenced against the limits set out in Condition G.3 of Waste License W0022-01.

2.2 HYDROCARBONS

Samples of the gas stream were extracted using low flow, intrinsically safe pumps at a flow rate of 200 ml/min. The pumps were calibrated before and after sampling. Organic Compounds in the gas stream were collected through specialised charcoal sorbent tubes (SKC 226-09). The sorbent tubes were analysed using a UKAS accredited laboratory (RPS Laboratories, Manchester, UK).

2.3 HYDROCHLORIC ACID & HYDROFLUORIC ACID

Samples of the gas stream were extracted using low flow, intrinsically safe pumps at a flow rate of 200 ml/min. The pumps were calibrated before and after sampling. Acids in the gas stream were collected through specialised charcoal sorbent tubes (SKC 226-10-03). The samples were analysed using a UKAS accredited laboratory (RPS Laboratories, Manchester, UK).

2.4 PARTICLAUTE MATTER

Total particulate measurements was carried out using extractive sampling under isokinetic conditions as outlined in British Standard BS: 3405 using a Stackmite Air/Dust Sampler. A sample of the flare gas was extracted through a sample nozzle of known cross-sectional area and a probe into a filter box to trap particulates. The filter box contained a 0.8-micron pore-size filter.

Before and after sampling, the glass fibre filters was dried in an oven at 103ºC, then reweighed by the RPS laboratory technicians, in order to gravimetrically determine the mass of particulate collected.

3 RESULTS

3.1 FLUE GAS ANALYSIS

The results of the flue gas emissions from the flare unit are presented in Table 3.1 below:

Table 3.1 - Results of Flue Gas monitoring from the Flare System at Rossmore Landfill

Parameter	Emission Value[1] (mg/Nm^3)	Emission Limit[2] (mg/Nm^3)
Nitrogen Oxides (NO_x) as NO_2	26	200
Carbon Monoxide (CO)	48	50
Sulphur Dioxide (SO_2)	37	N/A
Temperature (^0C)	1123.3	N/A

Note: 1 Normalised to 273K, 101.3 kPa and 3% O_2 reference.
Note: 2 As stated in Schedule G.3 of Waste Licence W0022-01.

3.2 TOTAL HYDROCARBONS

The results of the total hydrocarbons emissions (as Volatile Organic Compounds) from the flare system are presented in Table 3.2 below:

Table 3.2 - Results of Hydrocarbon Monitoring from the Flare System at Rossmore Landfill

Parameter	Emission Value (mg/m3)	Emission Limit [2] (mg/m3)
Total Hydrocarbons	<3.54	20

< denotes that the measured parameter was below the laboratory's level of detection.
Note: 2 As stated in Schedule G.3 of Waste Licence W0022-01

Results of the test showed no detectable volumes above the laboratory limit of detection.

3.3 HYDROCHLORIC AND HYDROFLOURIC ACID

The results of the HCl and HF of emissions from the flare system are presented in Table 3.3 below.

Table 3.3 - Results of HCl and HF monitoring from the Flare System at Rossmore Landfill

Parameter	Emission Value (mg/m3)	Emission Limit (mg/m3)
HCl	0.35	None Outlined in Waste Licence
HF	1.73	

*< denotes that the measured parameter was below the laboratory's level of detection of inorganic acids in the gas stream

3.4 PARTICULATE MATTER

The results of the Particulate emissions from the Flare Unit are presented in Table 3.4 below.

Table 3.4 - Results of Particulate Monitoring from the Flare Unit at Rossmore Landfill

Parameter	Emission Value (mg/m3)	Emission Limit (mg/m3)
Particulate Matter	*<0.01	None Outlined in Waste Licence

*< denotes that the measured parameter was below the laboratory's level of detection

4 CONCLUSIONS

The level determined for Nitrogen Oxides (NOx) from the Flare Unit are below the emission limit value stated in Schedlue G.3 of Waste License W0022-01.

The levels determined for Carbon Monoxide (CO) emissions from the Flare Unit were below the emission limit value stated in Schedule G.3 of Waste Licence W0022-01.

There are no limits for Sulphur Dioxide outlined in Waste Licence W0022-01, thus the results cannot is not comparable.

Total Hydrocarbons were determined as being below the limit of Schedule G.3 of Waste Licence W0022-01.

The levels determined for Hydrochloric Acid (HCl) and Hydrofluoric Acid (HF) are not comparable to Waste Licence W0022-01. However is the absence of a licence specific limit, the results can be compared to licence limits used by other similar landfill facilities. A limit of 50mg/m3 for Hydrochloric Acid and 5mg/m3 for Hydrofluoric Acid is enforced on most facilities, similar to Rossmore's landfill flare. In both cases, the HCL and HF concentrations detected during the flare test are below the fore mentioned limits.

The level determined for Particulate Matter is not comparable to Waste Licence W0022-01 due to the absence of a specific limit. The result determined during the survey is below the laboratory limit of detection, thus the concentrations can be considered extremely minimal.

All relevant parameters tested on the Rossmore Landfill Flare lie below the compliance limits of Waste Licence W0022-01. Given the results obtained from testing each parameter, the majority of concentrations can be considered low with respect to the relevant licence limit value and other comparable standards. Efficient combustion was thus observed from the Rossmore Flare.

Appendix A - Survey Details

Location

Rossmore Landfill,

Carrigtohill,

Co. Cork

Personnel Present

Ross Daly RPS Group Environmental Consultant

Date and Time

Wednesday, July 3rd, 2008

11.00 – 13.00

Equipment

High Temperature Probe and Atmospheric Pressure Probe

Testo Flue Gas Analyser

SKC Extraction Pumps

SKC Silica Sampling Media, Deionised Water and Glass Impingers

Stackmite 11 Dust & Gas Sampler

Flare Emissions Report
Rossmore Landfill
(Cork County Council)
DOCUMENT CONTROL SHEET

Client	Cork County Council					
Project Title	Monitoring of Flare Emissions at Rossmore Landfill					
Document Title	Emissions Monitoring 2008 – Biannual Monitoring Round 2					
Document No.	MCE0541Rp002					
This Document Comprises	DCS	TOC	Text	List of Tables	List of Figures	No. of Appendices
	1	1	4	1	-	1

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
D01	Draft	R. Daly	P. Barry	-	Innishmore, Cork	08/01/09

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APPENDIX

1 INTRODUCTION

Cork County Council commissioned RPS Group under the conditions of Fee Proposal No. MCE0541Fp001 to monitor emissions to atmosphere from an AFS flare unit at Rossmore Landfill, Carrigtwohill, Co. Cork.

The flare system is used to burn off landfill gas emitted from the decaying landfill waste and was sampled for emissions of Nitrogen Oxides, Carbon Monoxide, and Sulphur Dioxide.

This report presents the findings of the monitoring survey, which was conducted in compliance with EPA Waste Licence W0022-01.

2 MONITORING

Suitably qualified air quality personnel from RPS Group conducted the monitoring on the flare unit on December 3rd, 2008. The sampling and analytical methodologies employed are outlined below.

Monitoring of the Rossmore landfill gas flare emissions to atmosphere was the second biannual test of 2008. Monitoring of the following parameters was carried out: Flue Gas – Nitrogen Oxides, Carbon Monoxide, and Sulphur Dioxide.

2.1 FLUE GAS ANALYSIS

Flue gas emissions were measured using a Testo 350 flue gas analyser. This is a specialised flue gas analysis system fully equipped with electrochemical sensors. The Flue Gas Analyser measures the following parameters:

- Temperature
- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Sulphur Dioxide (SO_2)

Five sampling rounds were conducted over a 45-minute period. All the above are to be expressed at reference conditions of 273K, 101.3 kPa, dry gas and the correct oxygen reference for the combustion fuel.

Results will be referenced against the limits set out in Schedule G.3 of Waste License W0022-01.

3 RESULTS

3.1 FLUE GAS ANALYSIS

The results of the flue gas emissions from the flare unit are presented in Table 3.1 below:

Table 3.1 - Results of Flue Gas monitoring from the Flare System at Rossmore Landfill

Parameter	Emission Value[1] (mg/Nm^3)	Emission Limit[2] (mg/Nm^3)
Nitrogen Oxides (NO_x) as NO_2	18	200
Carbon Monoxide (CO)	47	50
Sulphur Dioxide (SO_2)	450	N/A
Temperature (^0C)	1010.3	N/A

Note: 1 Normalised to 273K, 101.3 kPa and 3% O_2 reference.
Note: 2 As stated in Schedule G.3 of Waste Licence W0022-01.

4 CONCLUSIONS

The level determined for Nitrogen Oxides (NOx) from the Flare Unit are below the emission limit value stated in Schedule G.3 of Waste License W0022-01.

The levels determined for Carbon Monoxide (CO) emissions from the Flare Unit were below the emission limit value stated in Schedule G.3 of Waste Licence W0022-01.

There are no limits for Sulphur Dioxide outlined in Waste Licence W0022-01, thus the results cannot is not comparable.

All relevant parameters tested on the Rossmore Landfill Flare lie below the compliance limits of Waste Licence W0022-01. Given the results obtained from testing each parameter, the concentrations are all below the relevant licence limit value. Efficient combustion was thus observed from the Rossmore Flare on December 3rd, 2008 concluding biannual sampling for 2008.

Appendix A - Survey Details

Location

Rossmore Landfill,

Carrigtwohill,

Co. Cork

Personnel Present

Ross Daly RPS Group Environmental Consultant

Date and Time

Wednesday, December 3rd, 2008

14.30 – 17.30

Equipment

High Temperature Probe and Atmospheric Pressure Probe

Testo Flue Gas Analyser