Silliot Hill Integrated Waste Management Facility
Kilcullen, Co. Kildare.

Waste Licence Ref: W0014-01

Annual Environmental Report - 2010

Original

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1. Introduction

On the 17th May 2002 the Environmental Protection Agency issued a waste licence to Kildare County Council for their integrated waste management facility at Silliot Hill, Kilcullen, Co, Kildare. The waste licence reference number is W0014-01. This report fulfils Condition 11.6 of the waste licence for the facility, which states that

"Within six months of the date of the grant of this licence, the licensee shall:

i) Submit to the Agency for its agreement, by 31st December 2002 and within one month of the end of each year thereafter, an Annual Environmental Report (AER).

ii) The AER shall include as a minimum the information specified in Schedule G: Content of Annual Environmental Report of this licence and shall be prepared in accordance with any relevant written guidance issued by the Agency."

This report addresses the items listed in Schedule G (Content of the Annual Environmental Report) of the waste licence for the facility. This AER covers the reporting period from 1st January 2010 up to 31st December 2010.

2. Site Description and Activities

2.1. Waste Activities carried out at the Facility

Waste activities at Silliot Hill Integrated Waste Management Facility (IWMF) are restricted to those outlined in Part 1 – Activities Licensed of the waste licence.

County Council vehicles, private contractors and members of the public access the facility. In summary, the site is divided into three active areas; the waste transfer station (WTS), the civic amenity facility (CA) and in-vessel composting area. The landfill and sludge treatment facility (STF) make up the fourth and fifth components. The activities carried out at each area are described in the subsections below.

2.1.1. Waste Transfer Station

The waste transfer station commenced operation in 2001. Construction of the enclosure of this transfer station commenced in October 2005 and was completed in June 2006. The facility is currently in use. It comprises an open floor area where vehicles enter from the east of the enclosure and deposit waste material in dedicated areas with bunker walls.

These dedicated areas in the WTS collect timber, bulky material, green material and metal. All mixed municipal waste is deposited in a single area.

There is a shredder in the WTS. Green waste is shredded on-site and stockpiled for disposal off-site. Timber waste is also shredded on-site and stockpiled until removal off-site. Bulky waste is shredded on-site and mixed with municipal waste prior to off-site disposal.

Members of the public are not permitted in the transfer station area.

2.1.2. Civic Amenity Facility

The activities in the civic amenity facility are licensed under Classes 3, 4 and 13 of the Fourth Schedule of the Waste management Act 1996. The operation of the CA is described as follows:

Recycling, baling and shredding of paper, cardboard and plastic takes place in a building at the north of the site. A hard standing area has been provided for the storage of these materials prior to their packaging within the building.

Adjacent to the site access road, a concrete hard-standing area is used for the deposition, collection and handling of bulky goods including green waste, white goods, glass and tyres. An area for the storage of household hazardous waste is located adjacent to this area. Members of the public can deposit waste at a designated area provided at the CA.

A charge for household recyclables was introduced in January 2009. This is tolled at a standard rate per volume. Household electronic goods are accepted of free of charge under the WEEE Regulations. Commercial white goods are charged. Bulky recyclables are tolled at a reduced rate. These items include tyres and scrap metal. Residual waste taken to the transfer station is charged at full toll.

Construction of the redesigned CA commenced in August 2005 and was completed in mid-2006. The facility was opened to the public in February 2007.

2.1.3. Greenstar In-Vessel Composting Area

Kildare County Council entered into a contract with SITA Recycling Ltd (now Greenstar) for the operation of a pilot in-vessel composting facility. These activities are licensed under Classes 6, 7 and 13 of the Third Schedule and Classes 2, 10, 11 and 13 of the Fourth Schedule of the Waste Management Act, 1996. The system was brought to site in April 2002 and was located adjacent to the WTS. The pilot in-vessel composting unit was relocated in September 2004 to a dedicated area including a composting building and yard area. The building and yard were completed in September 2004 and the newly located system was subsequently commissioned.

The technology used in the vertical compost units (VCUs) is of modular construction. There are four units installed at Silliot Hill, each with a capacity of 25m^3, giving a total capacity of 100 m^3. Each module can be operated and monitored independently of the others. With a 14 day cycle, the units can process 115 tonnes of food waste in that period (or 3,000 tonnes of food waste per annum).

Currently, this composting facility is not in operation and has not been functioning since 2007. As such, no results are reported here.

2.1.4. Old Landfill Site

The landfill site is located in an area previously used as a sand and gravel quarry. Landfilling operations ceased at the site in March 2002 following the commissioning of the WTS. Landfilling commenced in the early 1980s with the opening of a "dilute and disperse" type landfill (referred to as Phase 1).

Phase 1 covers an area of approximately 79,000m^2. Waste thickness is approximately 18m. Lined cells were constructed in 1997 (referred to as Phase 2). Phase 2 covers an area of approximately 24,000 m^2. Waste thickness in Phase 2 is also approximately 18m.

Phase 1 was capped in 1997/1998 with over 1m of low permeability clay and 300mm of topsoil. The Phase 1 area is divided into Phase 1a (the largest area to the east of the WTS) and Phase 1b (the isolated area to the north of the transfer station).

Phase 1a was generally found to have a significant clay cap, and the EPA agreed that this cap provides adequate protection to groundwater provided that localised areas receive augmented clay capping material and grading to control surface water run-off. Re-grading and augmentation of the clay cap and installation of gas and leachate infrastructure, and other associated infrastructure, was completed during 2008. 47 No. 1m diameter wells were installed during 2008 throughout Phase 1a and Phase 2 and connected into the facility's gas extraction system to improve gas capture.

Phase 1b received a fully engineered capping system inclusive of an integrated landfill gas extraction infrastructure. This was completed in early 2008.

Construction of a fully engineered capping system commenced in Phase 2 in mid 2008. This includes landfill gas and leachate collection infrastructure. The work was completed in June 2009.

Activities at the landfill area are now limited to the collection of landfill gas, the collection of leachate and the monitoring of environmental media.

2.1.5. Sludge Treatment Facility

The sludge treatment facility has ceased the intake of sludge since November 2002. The facility was constructed for the composting of stabilised sludge from Osberstown and Leixlip WWTPs.

Planning permission was granted to TEG Environmental in 2005 for the composting of food waste at the facility. This composting facility is complete but not being used at present. There is no commitment from the operators to return to the facility.

3. *Waste Quantities and Composition*

The quantity and composition of material received for recovery at the facility from 2000 to the end of the 2010 reporting period is outlined in Table 3.1.

Table 3.1: Summary of Recyclables Recovered (Tonnes) from Facility (2000-2010)

Material	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Shredded Greens	103.49	58.23	72.2	29.48	--	--	--	--	339.34	299.56	229.78
Scrap Metal	653.96	392.9	472.9	448.31	522.94	428.48	570.88	427	415.54	314.6	201.48
Bottles	16.08	15.5	46.01	69.26	93.31	108.83	107.16	109	112.58	71.98	52.76
Cans	--	--	--	8.54	16.38	14.68	12.42	9.428	3.62	18.6	9.1
Batteries	4.55	7.8	12.1	17.27	19.46	21.9	21.9	25.28	16.94	14.88	12.62
Glass Flat	4.32	19.26	8.09	30.79	45.43	38.11	30.84	27	15.86	15.16	9.22
Cardboard	168.74	158.37	187.99	216.91	294.5	297.5	274.58	349	278.66	221.7	165.76
Newsprint	47.01	51	39.57	125.71	153.17	135.2	115.76	129	128.36	82.42	62.6
Shredded Paper	--	--	--	237.77	133.83	120.5	114.14	30	41.56	44.7	32.34
Waste Oil & Filters	3.91	1.9	3.5	6.28	6.37	5.77	7.38	4	2.86	0	2.44
Electrical Goods	0.22	63.86	201.55	303.17	306.12	424.04	433.8	320.487	458.88	370.48	332.6
Gas Bottles	2.03	0.1	0.69	7.92	3.02	3.62	1.4	0	1.08	0.58	3.54
Clothes	4.61	--	4.28	7.74	10.46	17.69	31.64	46	47.22	26.36	18.86
Household Hazardous	--	--	--	12.93	23.96	24.44	30.18	36.28	29.76	18.74	19.98
Plastics	--	--	--	20.72	47.79	55.21	41.66	19	27.66	26.92	12.32
Ink Cartridges	--	--	--	0.04	--	--	0	0	0	--	
Tyres	0.71	--	--	--	4.9	15.01	0	8.28	19.53	7.24	9.16
Fluorescent Tubes	--	--	--	--	--	--	0.38	0.28	0.34	0.56	0.28
Polystyrene	--	--	--	--	--	--	--	--	2.52	0.84	
Gypsum	--	--	--	--	--	--	8.64	20.6	14.18	23.92	24
Totals	**1,009.63**	**738.92**	**1,048.88**	**1,542.84**	**1,681.64**	**1,710.98**	**1,793.74**	**1,560.653**	**1,956.48**	**1,656.26**	**767.58**

Table 3.2: Summary of Waste Recovered and Disposed (Tonnes) from Silliot Hill WTS 2010

Waste Type	Jan	Feb	Mar	April	May	June	July	August	Sep	Oct	Nov	Dec	TOTALS
Green Waste Out	-	39.58	-	44.88	9.16	37.96	41.5	27.44	-	29.26	-	-	**229.78**
Scrap Metal	9.02	21.16	16.92	27.56	15.02	35.5	7.68	27.18	25.42		16.02		**201.48**
Bottles	6.28	-	5.86	6.56	5.56	5.7	6.18	5.9	-	5.72	-	5	**52.76**
Waste Oil	-	-	0.8	-	-	0.86	-	-	-	0.78	-	-	**2.44**
Batteries	0.82	1.66	0.88	1.72	2.14		2.5	0.76	0.74		1.4		**12.62**
Bulk Waste	41.36	80.4	42.8	33.84	58.3	160.64	80.8	16.08	87.28	95.64	41.26	45.64	**784.04**
Fluorescent Tubes	0.02	-	-	-	0.08	-	-	0.16	-	-	0.02	-	**0.28**
Tyres	-	-	-	9.16	-	-	-	-	-	-	-	-	**9.16**
Gas Bottles	1.5	-	-	-	1.6	-	0.2	-	-	0.24	-	-	**3.54**
Clothes	1.84	1.14	1.94	1.82	1.6	2.06	2.2	1.3	1.76	1.48	1.12	0.6	**18.86**
Flat Glass	-	1.54	-	2	-	2	-	2.8	-	-	0.88	-	**9.22**
Shredded Paper	-	4.6	4.02	-	5.04		-	9.12	-	-	9.56	-	**32.34**
Cans	-	-	-	-	-	-	-	-	-	-	9.1	-	**9.1**
Polystyrene	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Plastics	-	-	-	1.28	-	-	-	11.04	-	-	-	-	**12.32**
Electrical	28.88	28.88	26.28	40.08	30.08	36.4	27.3	33.66	29.78	17.52	25	8.74	**332.6**
Household Haz.	-	-	4.22	3.94	-	6	-	2.36	-	-	3.46	-	**19.98**
Gypsum	-	3.38	-	2.78	2.22	1.78	2.38	1.58	4.94	2.3	-	2.64	**24**
Cardboard	16.6	14.26	20.14	11.86	10.94	22.4	20.8	12.82	15.2	15.62	5.12	-	**165.76**
Newsprint	5	5.92	9.32	5.48	4.72	6.08	5.08	5.68	5.42	4.46	5.44	-	**62.6**
Waste Cooking Oil	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Mixed Residual Waste	1699.56	1597.78	2000.26	1893.02	823.80	385.44	345.1	425.32	301.28	237.5	321.74	294.14	**10324.98**
Timber	-	-	10.72	-	-	13.68	-	-	-	-	-	-	**24.4**
TOTALS	**1810.88**	**1800.30**	**2144.16**	**2085.98**	**970.26**	**716.50**	**541.72**	**583.20**	**471.82**	**410.56**	**440.12**	**356.76**	**12332.26**

Tables 3.1 and 3.2, above, outline the trend for the recovery of recyclables during the period from 2000 to 2010. The total for 2010 shows a continued decrease in overall material handled from the previous years (mainly influenced by WEEE, scrap metal, cardboard and clothing decreases).

As of June 2008 bulky waste is shredded onsite and disposed off with the mixed waste.

There was no waste delivered to the Greenstar In-Vessel composting facility during the reporting period. The composting facility was closed down by the Department of Agriculture and will remain closed for the foreseeable future.

All waste quantities handled at each of the areas are within the tonnages licensed for Silliot Hill.

4. Settlement and Slope Stability

4.1. Settlement

As documented in previous AERs, annual topographical surveys carried out since the granting of the waste licence indicate that Phase 1 has stabilised (i.e. little or no settlement is occurring).

In Phase 2, the 15-month interval between surveys in July 2005 and October 2006 the average annual settlement rate was recorded as 190 mm/year. This represented a decrease in the settlement level experienced at Phase 2 in 2005 which was estimated at 530 mm.

In preparation for the capping of Phase 2 and its respective gas extraction infrastructure a surcharge of clay material was installed early 2007. The purpose of the surcharge was to accelerate onsite consolidation facilitating installation of the capping works. As a result of the extensive works carried out on Phase 2 a base-line topographical survey was completed in 2009. The topographical survey for 2010 shows some settlement in Phase 2.

4.2. Slope Stability

A slope stability analysis was conducted for the site by Golders Associates. Their report concluded that the slopes surrounding the transfer station are not showing signs of deterioration. This coupled with the detailed assessment undertaken by Fehily, Timoney & Co. in 2009 means that the slopes are stable. The report on the slope stability assessment in included in Appendix V.

5. Summary of Environmental Monitoring

Condition 8 and Schedule D of the waste licence specifies the environmental monitoring requirements of the facility. Conditions 8.5 to 8.11 list the parameters to be monitored. The following sections discuss the results from the four quarterly monitoring and annual monitoring events during the reporting period.

5.1. Landfill Gas

The licence requires that the licensee conduct monthly monitoring in the gas wells in order to detect off-site gas migration and weekly monitoring in site buildings in order to detect accumulation of landfill gas. The gas is monitored using a "GFM420" or "GA2000+" automatic infra-red analyser/electrochemical cell which detect atmospheric pressure and levels of carbon dioxide, methane and oxygen.

The location of the monitoring positions is shown on Drawing 2001-114-01-003-RevD, contained in Appendix I. The monitoring results for 2010 are attached in Appendix II.

5.1.1. Interpretation of Results

Site Buildings

Gas concentrations in the site buildings are monitored on a weekly basis. To date methane and carbon dioxide readings have been zero. Oxygen has been recorded at normal levels. Automatic gas detection/alarm systems were installed in the site offices in November 2003. No incidences have been recorded.

Gas Boreholes and Wells

Lateral migration of landfill gas at Silliot Hill has been recorded since late 1997, following the capping of Phase 1 (the unlined portion of the landfill). Gas migration was brought under control by the installation of an active gas extraction system in 1998. The gas collected was used to fuel two open flare systems until November 2003. An enclosed flare which had been installed as part of the new landfill gas management programme was then brought on line and the two open flares decommissioned. This enclosed flare received gas from the perimeter of the landfill. In March 2004 the landfill gas utilisation plant was put into operation to receive the gas from the core of the landfill. No gas was flared in 2008 owing to the onsite construction works. Flaring recommenced in June 2009 following completion of the new gas collection infrastructure.

A number of new perimeter gas wells were bored and installed around the site during 2007 to replace some of the older existing wells which have been identified as performing poorly and some other wells that have been damaged during construction works onsite. Permission to start monitoring these wells was granted by the Agency in June 2008.

During the 2010 reporting period the area of significance was along the southern boundary of the site. Gas levels above the trigger level were most prevalent along this boundary of the landfill. Persistent raised methane levels have been recorded at the TEG building and close to the entrance to KTK landfill at G103, G104D, G104S, G105 and G106D. Carbon dioxide exceedences were also prevalent in these wells.

Patterns of gas migration have improved since the recommencement of flaring in the middle of 2009. A landfill gas balancing model commissioned from Fehily, Timoney and Co was received at the end of 2009. It is hoped that the use of this tool will fine tune the gas management and continue the downward trend of exceedences.

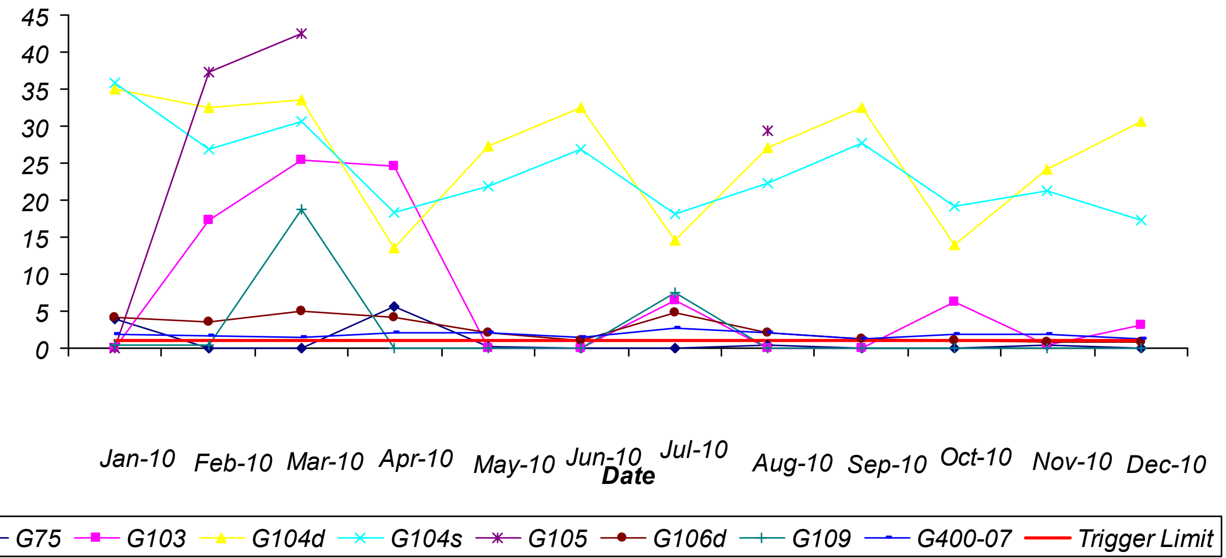


Figure 5.1. Perimeter Gas Wells Exceeding Methane Trigger Level (2010)

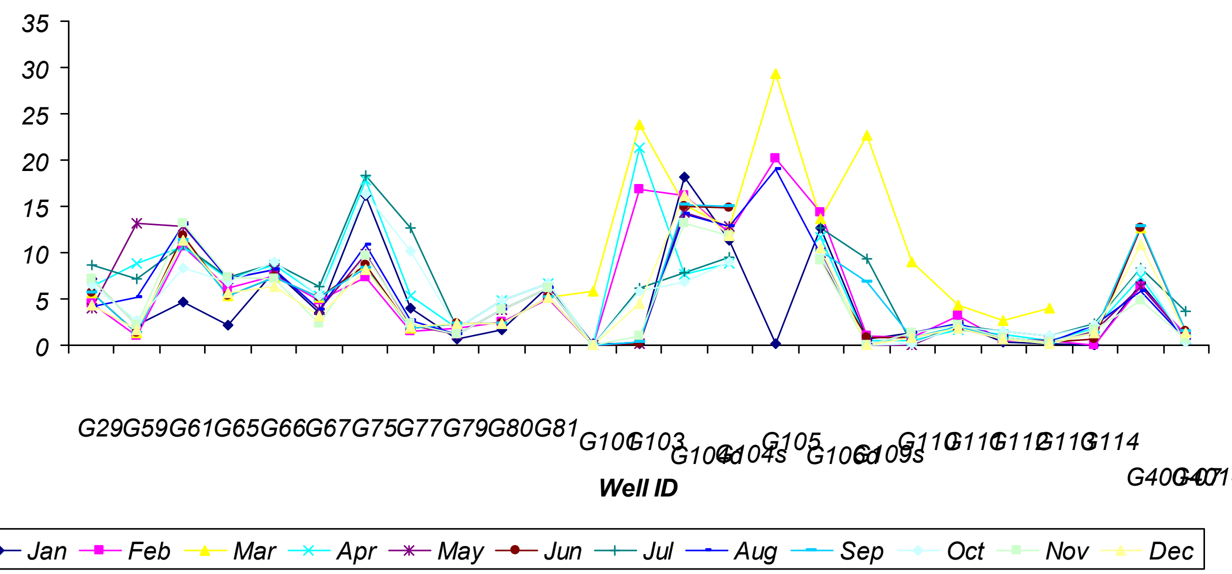


Figure 5.2. Carbon dioxide Readings in Perimeter Gas Wells (2010)

5.2. Surface Water

Surface water monitoring was carried out at the seven locations (SW1 to SW7) as outlined in Table 5.1 and shown on Drawing 2001-114-01-003, Rev D. SW5 was found to be dry during every site visit in 2010. The results of the monitoring are presented in Appendix II.

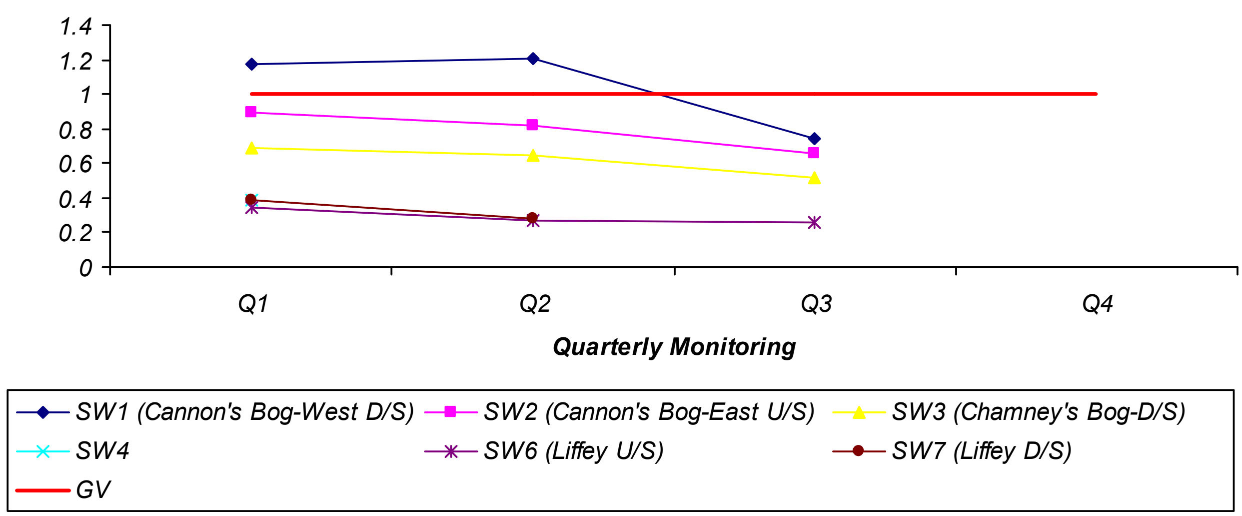
Table 5.1. Surface Water Monitoring Locations

Station	Easting	Northing	Location
SW1	285216	210323	Westerly drain from Cannon's Bog
SW2	285368	210422	Drain downgradient of SW5
SW3	285835	210674	Drain downgradient of SW4
SW4	285789	211010	Drain nearest the site – 200m
SW5	285444	210963	Drain near the site – 250m
SW6	285690	210079	Upgradient – R. Liffey
SW7	285278	210178	Downgradient – R. Liffey

5.2.1. Interpretation of Results

The surface water results have been compared to limits as outlined in the Surface Water regulations, 1989, for comparative purposes only. It can be seen from the results that over the course of the year, several parameters were above the trigger level as specified in the regulations.

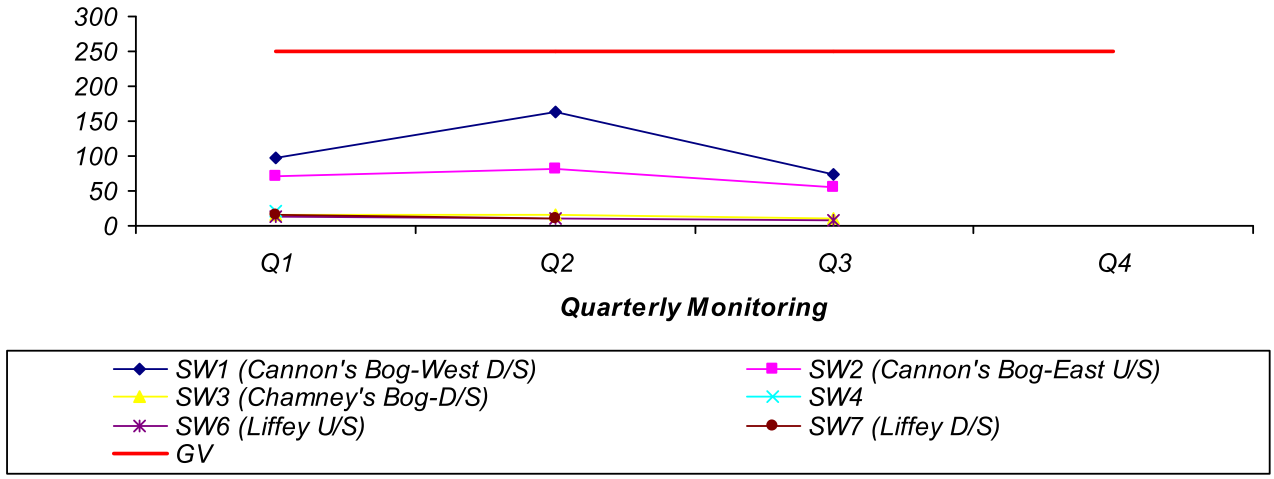
SW1 and SW2 have higher indicator values than the other sites. Three of these parameters, conductivity, chloride and Ammonia, are plotted for quarterly data in Figures 5.3, 5.4, and 5.5 respectively. These parameters were chosen because they are indicators of leachate impact, but they may also demonstrate impact from other sources, such as sewage or industrial effluent.



Note: U/S – upstream, D/S – downstream

Figure 5.3. Conductivity at Surface Water Monitoring Points (2010)

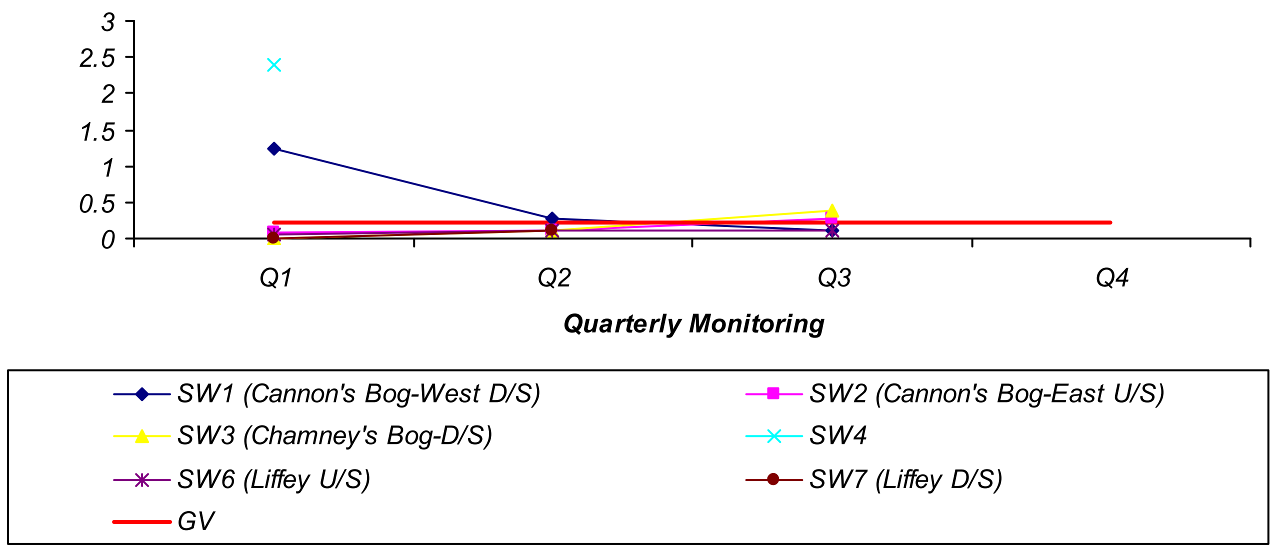
The above graph indicates a possible impact from the landfill on SW1. However, these surface water channels are known to receive inputs from an industrial estate outside Kilcullen, which is upstream of the landfill and thus may have contributed to the water quality downstream. There is no discernable deterioration of the River Liffey at the downstream monitoring point, SW7.



Note: U/S – upstream, D/S – downstream

Figure 5.4. Chloride at Surface Water Monitoring Points (2010)

It is likely that the elevated levels of chloride are caused by the same sources as those causing the high conductivity levels. It should be noted that chloride levels at all sites were below the trigger limit of 250 mg/l Cl



Note: U/S – upstream, D/S – downstream
Where samples were below limit of detection, half the detection limit was used to plot the graph

Figure 5.5. Ammonia at Surface Water Monitoring Points (2010)

Ammonia levels in SW1 were elevated throughout the year, but dropped below the trigger level of 0.23 mg/l N in Quarter 3. Ammonia was also high in SW 4 in Quarter 1. Ammonia levels were below the trigger level at all other sites throughout the year apart from Q3 when there was an increase at SW2 and SW3. SW2 is upstream of the landfill and therefore the cause is unlikely to be the landfill. The cause of the increase in SW3 is unknown.

5.3. Groundwater Quality

Groundwater monitoring is carried out at the locations outlined in Table 5.2. New monitoring infrastructure was approved in late 2008. This increased the number of groundwater wells from 18 to 19.

Table 5.2. Groundwater Monitoring Locations

Station	Easting	Northing	Location
BH 1	285832	211804	Upgradient
BH 2	286040	211673	Adjacent
BH 3	285591	211719	Adjacent
BH 4-07	285714	211459	Down Gradient
BH 9D	285797	211904	Upgradient
BH 10D	285422	211548	Down Gradient
BH 11D	285136	211307	Down Gradient
BH 13-07	285714	211459	Upgradient
BH 15-07	285795	211888	Upgradient - Dry
BH 16R-07	285909	211412	Down Gradient - Dry
KTK 20	285663	211082	Down Gradient
GWR 1	285198	210319	Down Gradient
GWR 2	285741	210609	Down Gradient
GWR 3	286187	210813	Down Gradient
PW 2-09	285769	212262	Upgradient
PW 4	285603	211798	Upgradient
PW 9	285940	210264	Down Gradient
PW 11	285495	210638	Down Gradient
PW 15	285663	211835	Upgradient - Dry

The groundwater monitoring locations are illustrated on Drawing 2001-114-01-003 Rev D (Appendix I). It should be noted that on all sampling occasions BH10D, BH15-07, BH16R, BH16R-07 and PW15 have been dry or had insufficient water to purge and sample.

5.3.1. Interpretation of Results

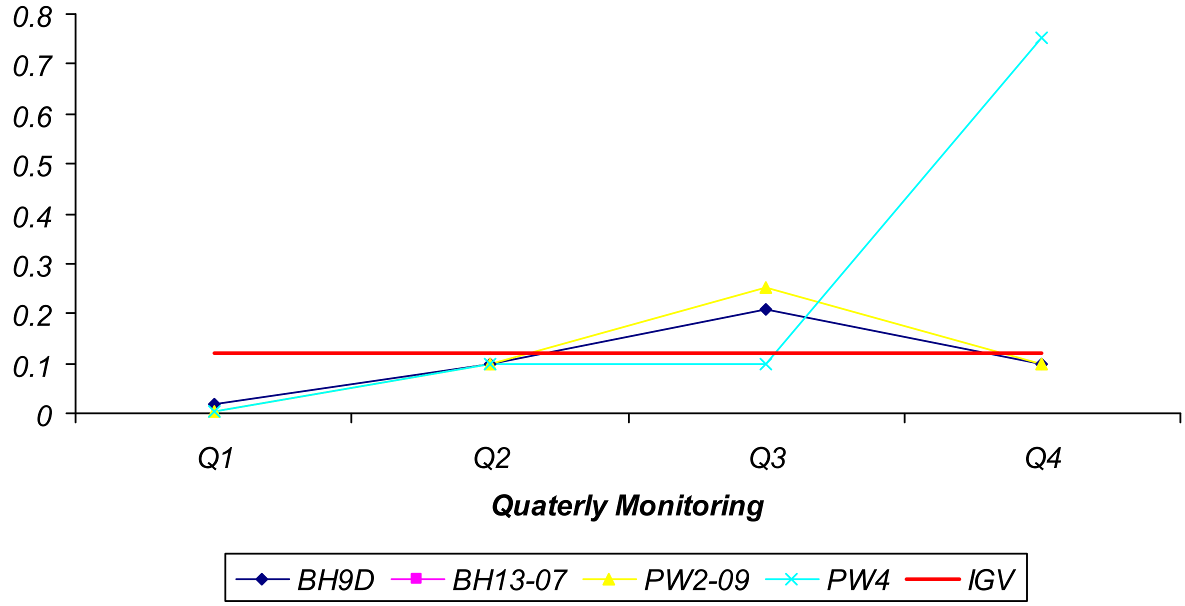
The groundwater results have been compared with the relevant Interim Guideline Value (IGV) set out in the EPA report 'Towards Setting Guideline Values for the Protection of Groundwater in Ireland'.

Groundwater upgradient of the site is impacted by agricultural and septic tank point sources as demonstrated by elevated total coliforms at all wells and faecal coilforms in BH9D, PW2-09 and PW4. Throughout the year Ammoniacal nitrogen and chloride at BH9D and PW2-09 substantiate this interpretation.

Groundwater beneath the landfill and directly downgradient of it shows impact from the unlined portion of the landfill. BH2, BH3 and BH4-07 all have elevated levels of ammoniacal nitrogen and total coliforms. BH4-07 has elevated levels of potassium, sodium and chloride also.

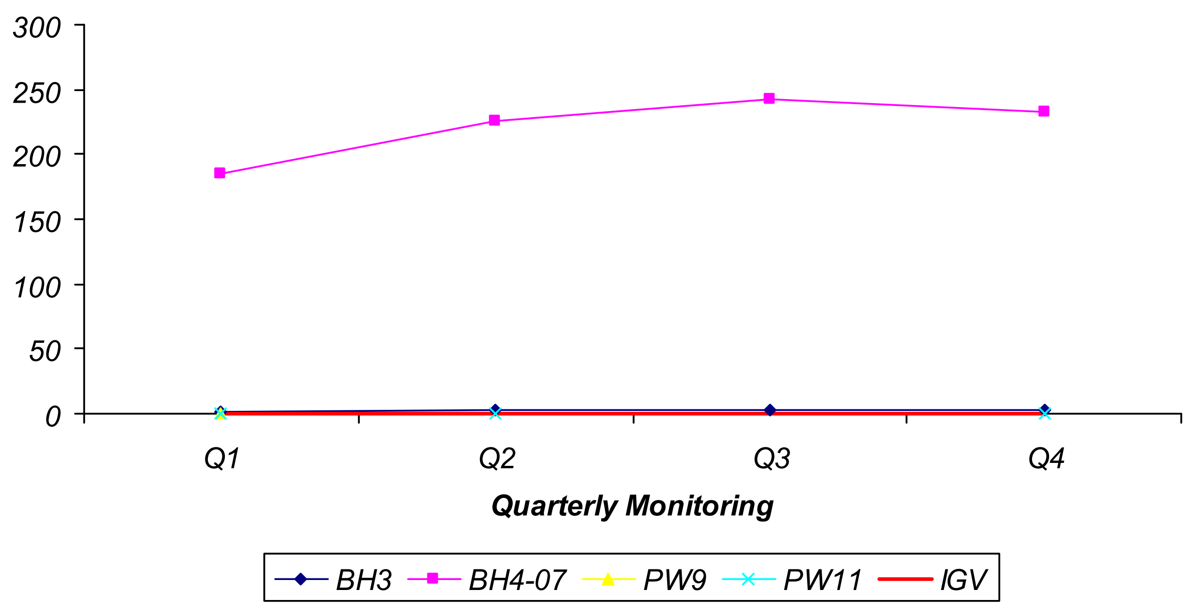
BH15-07, BH16R (and its replacement BH16R-07), PW15 and on occasion BH10D have had insufficient volumes of water for sampling. During the year sampling tubing has fallen down both BH1 and BH2 blocking them.

The contamination resulting from the unlined portion of the landfill does not extend a significant distance from the landfill as shown by the results for BH11D and KTK20 which are located greater than 100m south of the landfill.



Note: Where levels were below the limit of detection, half the limit of detection was used for plotting the graph

Figure 5.6. Ammoniacal Nitrogen Levels at Upgradient Groundwater Monitoring Points (Compared to Interim Guideline Value)



Note: Where levels were below the limit of detection, half the limit of detection was used for plotting the graph

Figure 5.7. Ammoniacal Nitrogen Levels at Downgradient Groundwater Monitoring Points (Compared to Interim Guideline Value)

None of the private wells down gradient of the facility appear to be affected by the landfill (see results for PW9 and PW11 in Appendix II). Though there are instances of high coliform counts and failure of other water quality standards, local sources of contamination (farmyards, septic tanks or poor wellhead protection) are believed to be the cause of this microbiological and physio-chemical contamination.

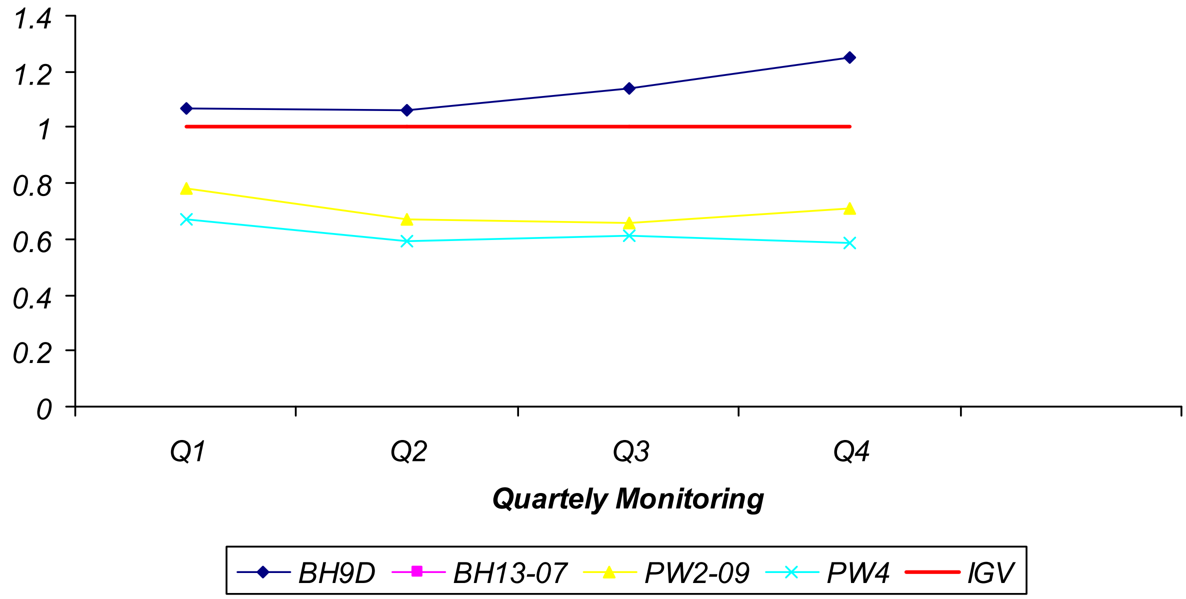


Figure 5.8. Conductivity Levels at Upgradient Groundwater Monitoring Points (Compared to Interim Guideline Value)

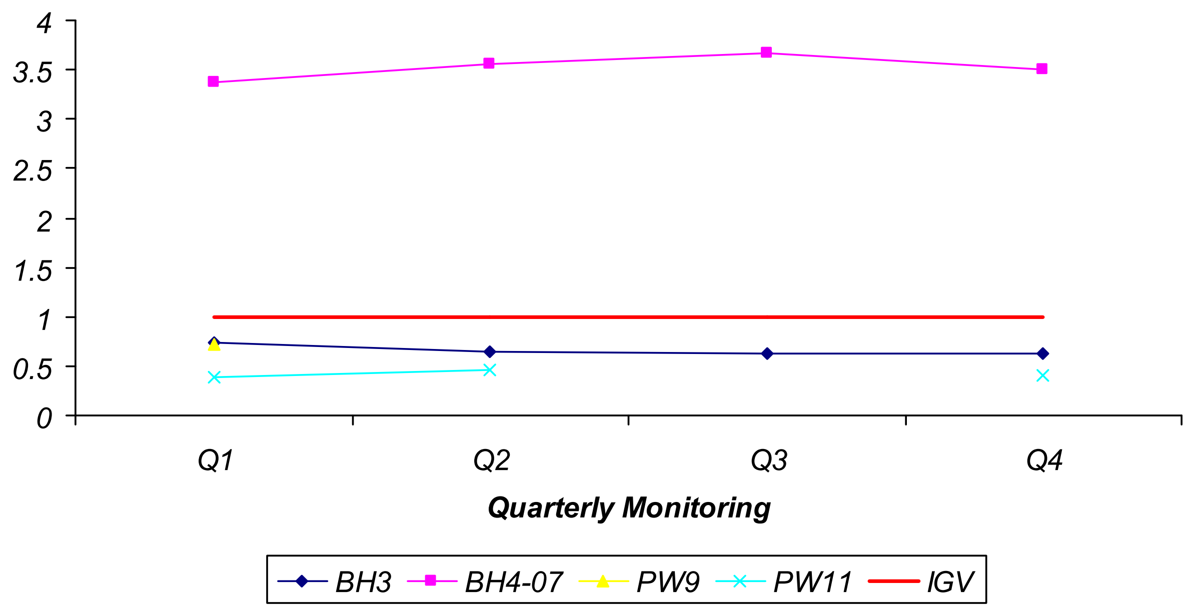


Figure 5.9. Conductivity Levels at Downgradient Groundwater Monitoring Points (Compared to Interim Guideline Value)

5.4. Leachate

Leachate monitoring is carried out at the six locations (L1 to L6) outlined in Table 5.3 and shown on Drawing 2001-114-01-003 (Rev D) in Appendix I. The results of the monitoring are presented in Appendix II

Table 5.3. Leachate Monitoring Locations

Location	Eastings	Northings
L1	285607	211587
L2	285775	211483
L3	285750	211685
L4	285717	211753
L5	285747	211664
L6	285834	211587

L5 and L6 were damaged during the capping works and have become blocked. Therefore, a sample could not be obtained from either of these leachate sumps. Two of the large diameter gas wells have been used as replacements for L5 and L6

5.4.1. Interpretation of Results

Figure 5.9 shows the levels of conductivity measure at leachate wells throughout the year and these are typical concentrations for leachate

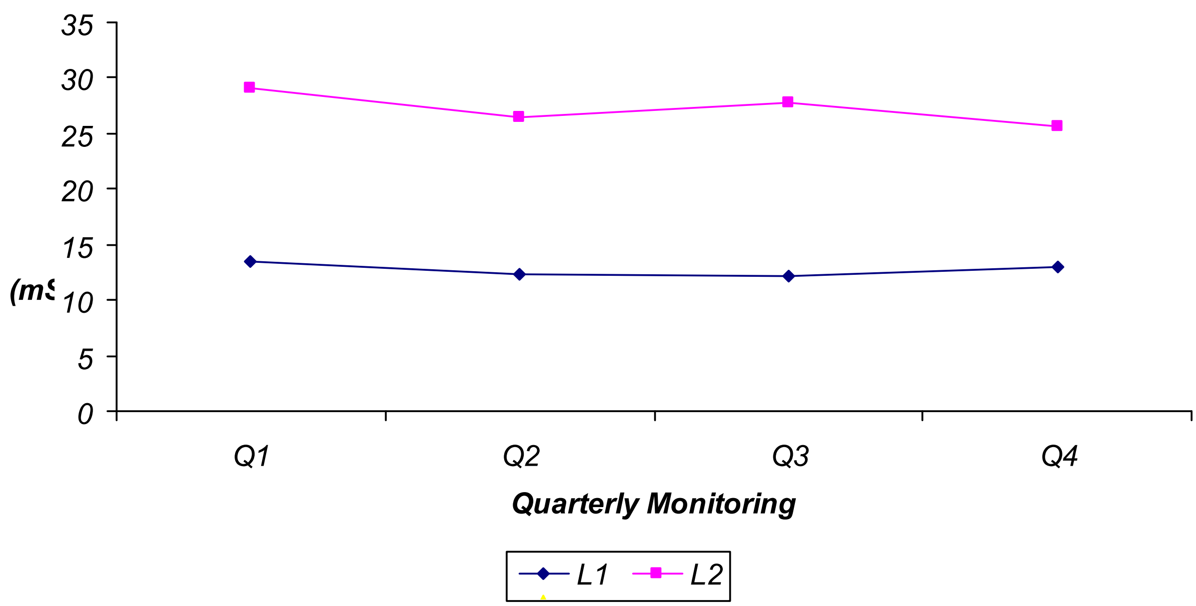


Figure 5.10. Conductivity Levels at Leachate Monitoring Points.

L3 and L4 are manholes that receive foul drainage from the hard-standing areas on-site and hence, have chemistry similar to contaminated storm water rather than pure leachate. L3 also has a high total and faecal coliform count.

5.4.2. Leachate Level Results

Leachate levels are monitored on a weekly basis at L1 and L2, to assess the head of leachate above the liner at these locations. Condition 5.9.2 of the Waste Licence states that 'leachate levels in the waste shall not exceed a level of 1.0m over the top of the liner at the base of the landfill in Phase 2'. Access to L1 and L2 was restored at the end on November 2009. Figure 5.10 illustrates the weekly leachte levels at L1 and L2 from November 2009 to December 2010.

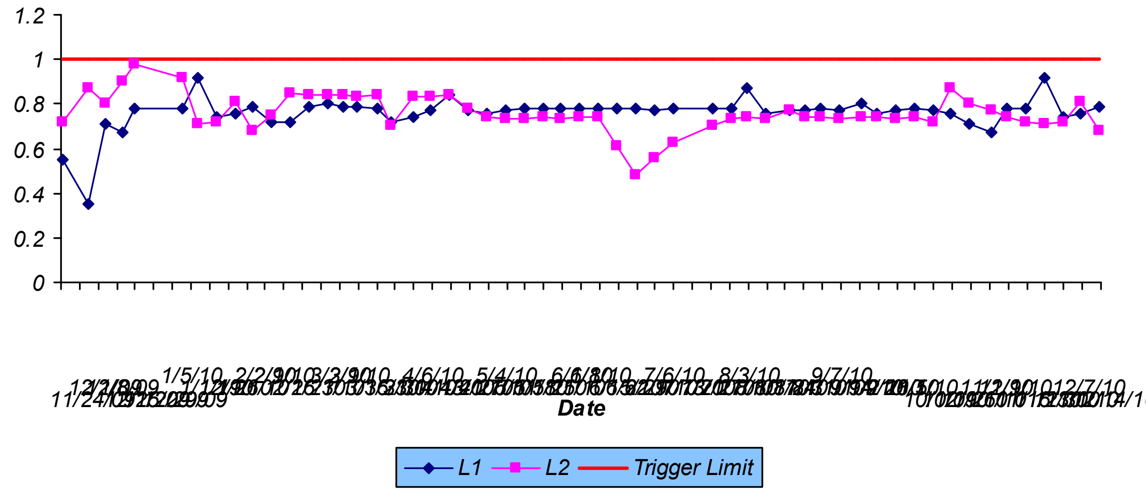


Figure 5.11. Leachate Levels at L1 & L2

Leachate levels in L1 and L2 have not exceeded the limits of 1m over the liner. As part of the capping works new pumps and level sensors were installed in both of the leachate sumps. The level sensors are connected into the SCADA system which automatically and continuously monitors the levels of leachate in L1 and L2.

5.5. Noise

As per schedule D of the Waste Licence, the annual noise survey was carried out on 12/10/2010 and on the 25/11/2010. The weather conditions were suitable. Noise monitoring was undertaken at the 7 locations as shown on Drawing 2001-114-01-003 Rev D

Noise monitoring was carried out on the 12/10/2010 between the hours of 11:00 and 17:00 for 30 minute intervals at each location and on 25/11/2010 between the hours of 15.00 and 17.00 for 30 minute intervals at each location. No night time noise monitoring is required at the facility. All measurements were taken in accordance with ISO 1996 (Description and Measurement of Environmental Noise) and the EPA Environmental Noise Survey Guidance Document.

The survey was carried out using a Brüel and Kjær 2250 Type 1 Sound Level Meter (SLM) with an outdoor microphone unit Type 4198.

The instrument was calibrated prior to commencing the survey using the recommended calibration procedure and a known pure tone noise source. The unit was again calibrated on completion of the survey to record drift during the course of the day. Drift is normally associated with battery fade and temperature. The unit had not drifted.

Good measurements require calm conditions to avoid spurious effects on the microphone, particularly at low frequencies. An average wind speed of less than 5 m/s is the preferred limit when noise measurements are being taken, with 7 m/s an upper limit. Weather conditions during the 2 days of monitoring were dry, bright and with a wind speed of less than 5m/s for the entire period

Noise monitoring was carried out at the seven locations (N1 to N7) outlined in Table 5.4 and shown on Drawing 2001-114-01-003 Rev D. Noise measurements were taken for 30 minutes at each location. A summary of the monitoring results are presented in Table 5.5

Table 5.4. Noise Monitoring Locations

Location	Eastings	Northings
N1	285651	211809
N2	285930	211815
N3	286083	211704
N4	285938	211554
N5	285838	211494
N6	285540	211617
N7	285633	211489

5.5.1. Interpretation of Results

Four of the seven noise stations monitored were in exceedance of the EPA limit of 55 dB (A) for daytime noise. The dominant sources of noise at N1, N4, N6 and N7 were not caused by activities at the Silliot Hill facility. Traffic on the R448, Carnalway Road and traffic to and from the KTK landfill are the main contributors to noise levels in the area. Also another dominant noise source at N6 was the truck idling in the yard where the noise monitoring was being taken.
The exceedance at monitoring points N6 and N7 are only slightly above the EPA Limit of 55 dB(A).

All the L_{AF90} readings are under the EPA limit for dB. This indicates that the intermittent noise for less than 10% of the monitoring period caused the greatest impact. Traffic sounds would normally fall into the L_{AF10} range.

5.5.2. Assessment of Tonal Components

All noise measurements were subject to a one-third octave band analysis to identify tonal components within the noise measured and the results of this analysis are presented in Appendix 2. Tonal noise was not recorded at any of the monitoring points.

Table 5.5. Noise Results

Location	Date	Time	2010 L(A) EQ	2010 L(A) F10	2010 L(A)F 90	Noise Source
N1	25/11/2010	15.22	61.5	65.7	46.1	Traffic on R448 is the dominant noise source at this location. On site noise from traffic and activities at the civic amenity site and distant noise from other activities off site could be heard in the background.

N2	12/10/2010	12.49	47.9	50.7	42.3	Dog barking and noise from traffic and birdsong could be heard in the background. Jeep and trailer drove though the site during noise monitoring.
N3	12/10/2010	16.05	43.5	45.1	39.8	Dominant noise is the electricity pylon. Background noise is from traffic on the Carnalway Road , agricultural machinery noise and dog barking.
N4	12/10/2010	15.24	59.1	57.6	51.6	Dominant noise is traffic on the R448 and traffic accessing KTK landfill. Background is coming from the gas utilisation plant at KTK, machinery operating on site, beeping from trucks working on KTK site, aircraft over head and some birdsong.
N5	25/11/2010	16.01	52.2	53.8	45.1	Dominant noise was traffic on the Carnalway Road to KTK Site . Background noise is coming from children out playing and activities at Kilsaran Quarry.
N6	12/10/2010	12.07	56.2	60	42.4	Dominant noise is a truck idling on site, car driving into site and traffic on R448. Continuous birdsong could be heard and background noise included JCB bucket banging at Silliot hill and dogs barking.
N7	12/10/2010	11.17	55.9	60.2	44.6	Traffic on the Carnalway Road to KTK Landfill and on R448 provides the dominant noise sources. Background noise came from birds singing and the blower in Methane stripping plant.

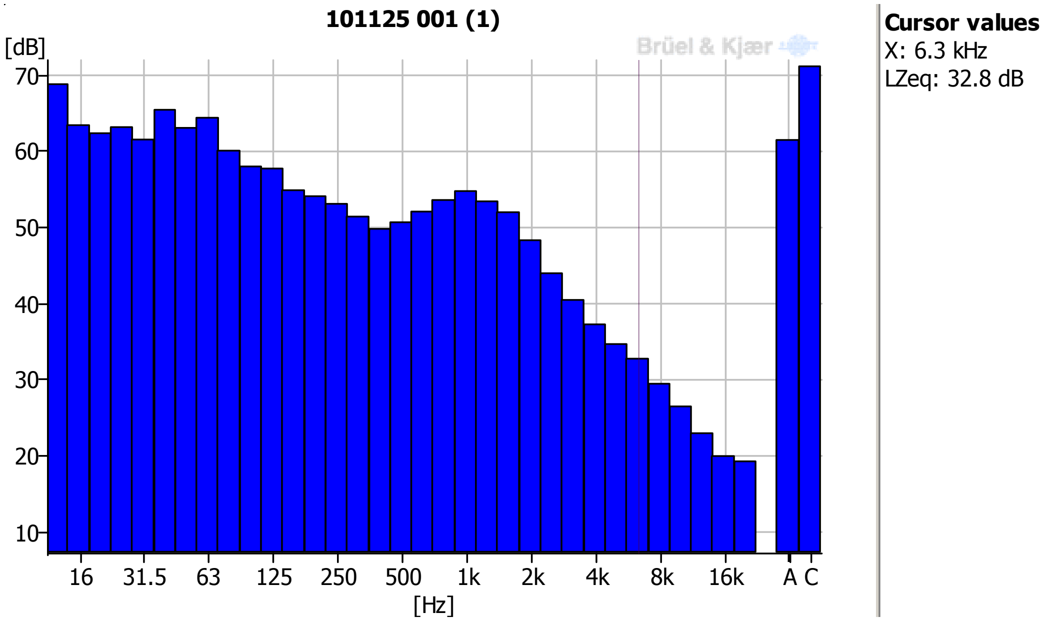


Figure 5.12 Noise Location N1 1/3 Octave Band Analysis

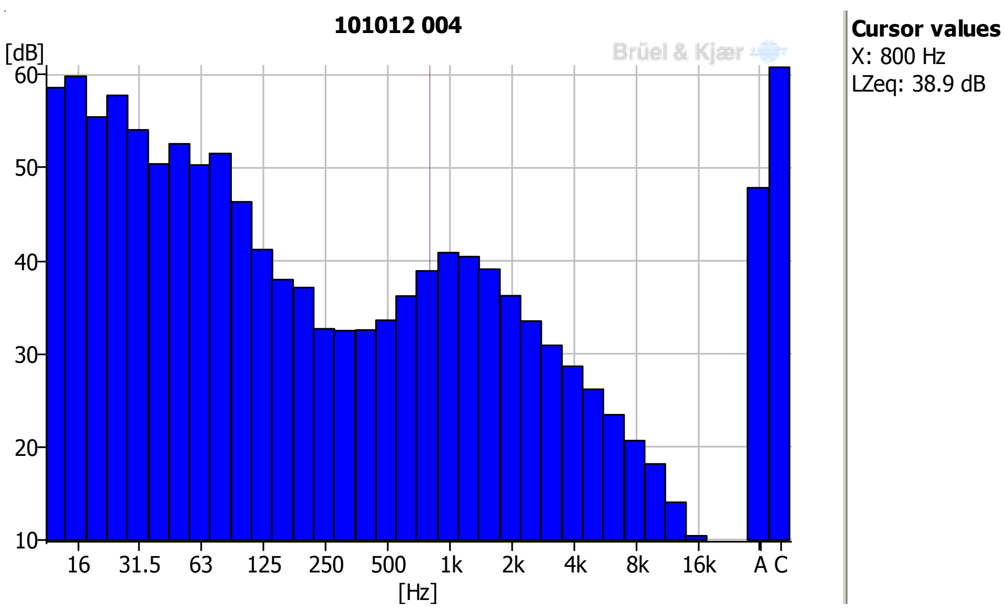


Figure 5.13 Noise Location N2 1/3 Octave Band Analysis

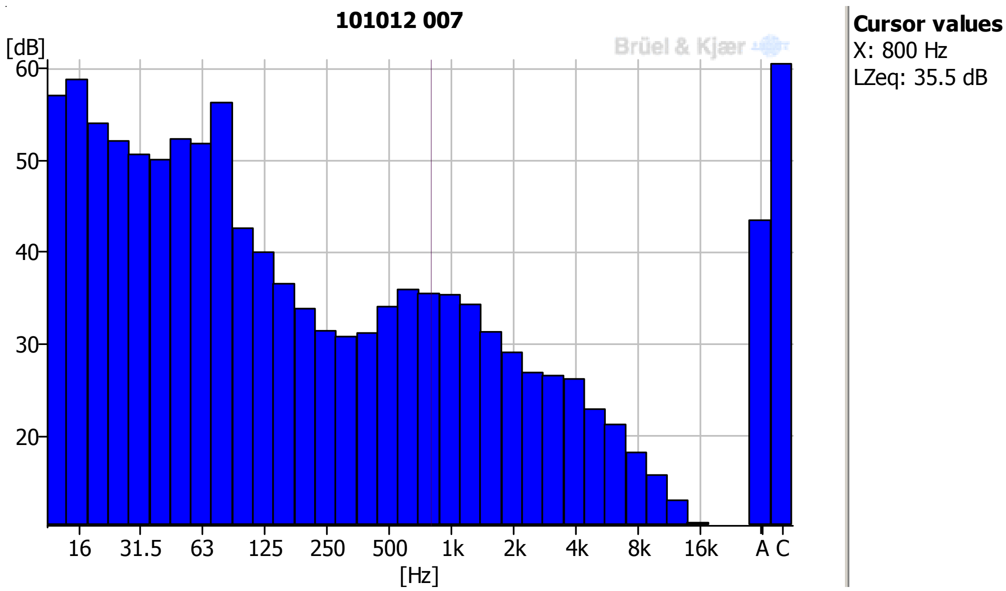


Figure 5.14 Noise Location N3 1/3 Octave Band Analysis

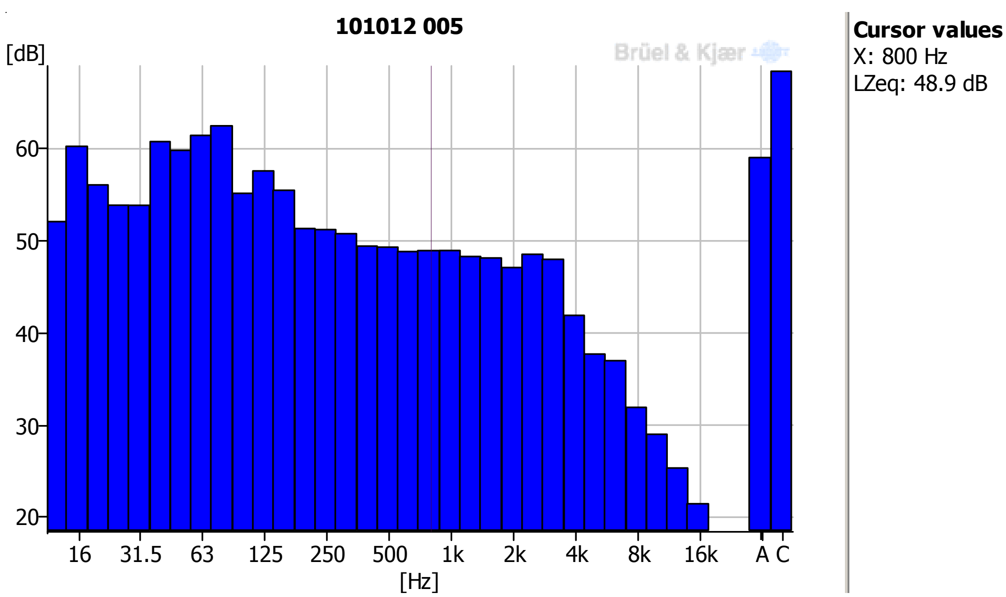


Figure 5.15 Noise Location N4 1/3 Octave Band Analysis

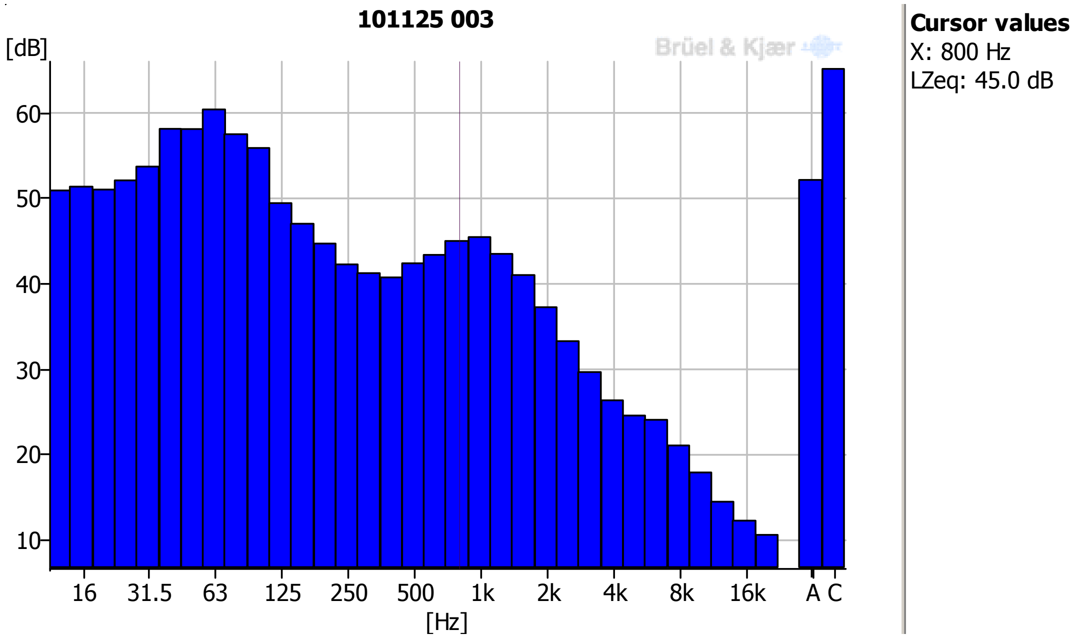


Figure 5.16 Noise Location N5 1/3 Octave Band Analysis

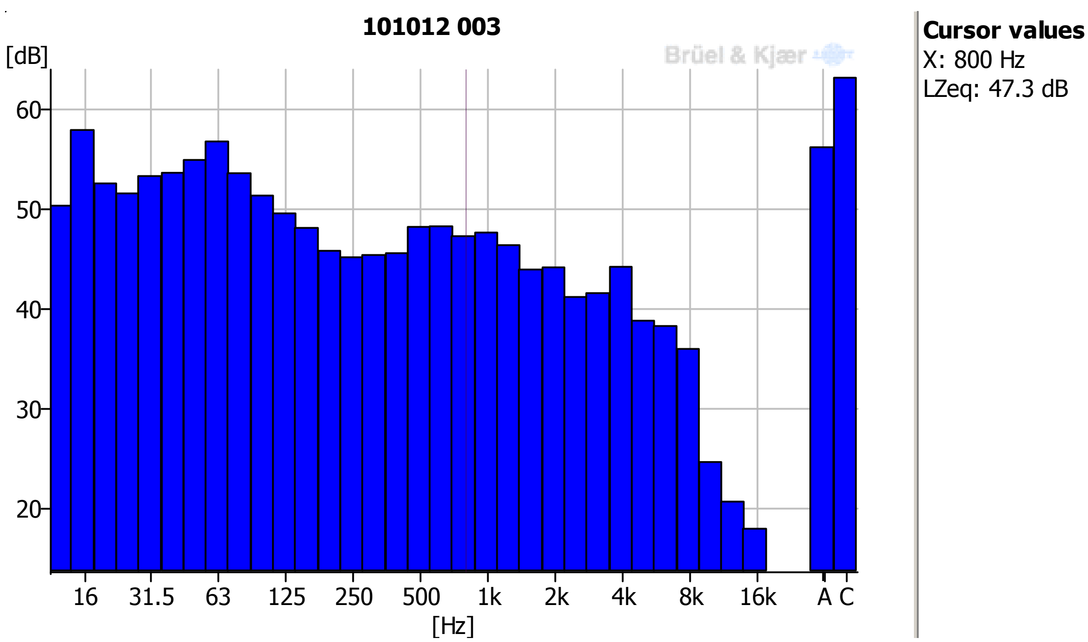


Figure 5.17 Noise Location N6 1/3 Octave Band Analysis

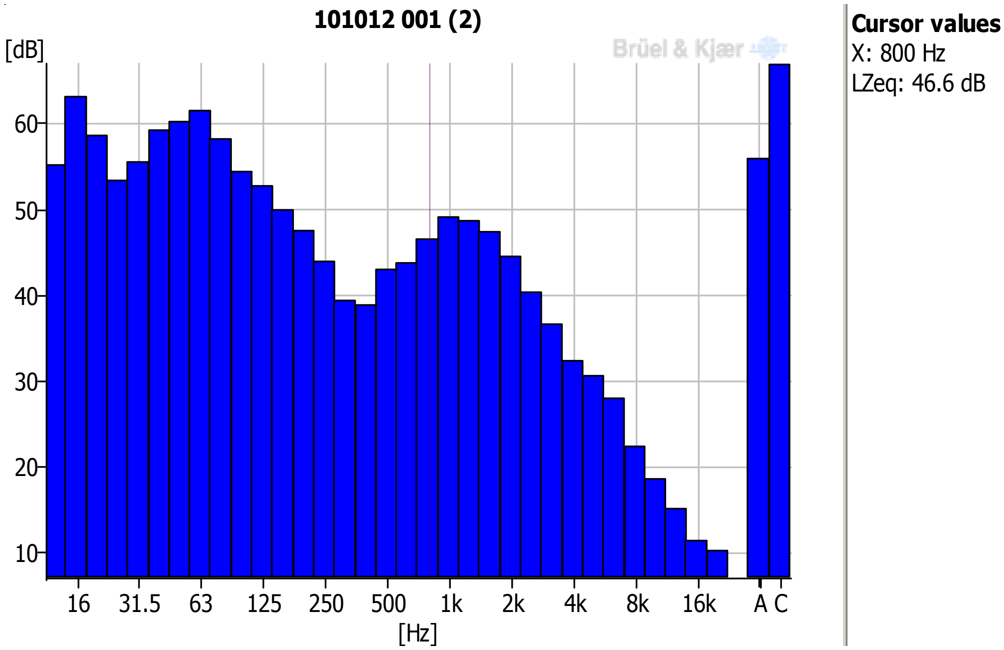


Figure 5.18 Noise Location N7 1/3 Octave Band Analysis

5.6. Air Monitoring

Air monitoring was carried out in accordance with the licence with the licence at six locations (D1 to D4 & D6 to D7) as outlined in Table 5.6 and shown on Drawing 2001-114-01-003 Rev D. The results of the monitoring are presented in Appendix II.

Table 5.6 Dust Monitoring Locations

Station	Easting	Northing	Location
D1/PM_{10}1	285707	211809	Entrance to facility
D2	285931	211815	Northern perimeter of facility
D3	286083	211704	NE perimeter of Phase 1
D4	285938	211554	Eastern perimeter of Phase 1
D5	285838	211494	SE perimeter of Phase 1
D6/PM_{10}2	285540	211617	Western perimeter of Phase 2
D7/PM_{10}3	285633	211489	Southern perimeter of landfill

5.6.1 Interpretation of Results

No determination of dust could be made during analysis for the 2010 monitoring periods.

All PM10 results were within the 50 $\mu g/m^3$ limit as recommended in the Air Quality Standards Regulations (SI No. 271 of 2002).

5.7. Compost

No waste material was taken into the site for composting during the monitoring period. Consequently, compost quality has not been analysed during this year and the composting facility remains closed for the foreseeable future.

5.8. Climate

The annual rainfall figures recorded at KTK Greenstar are presented in Table 5.7 and illustrated in Figure 5.18.

Table 5.7. Monthly Rainfall, Evapotranspiration and Temperature Data 2010

Month	Rainfall (KTK) (mm)	Evapotranspiration (Casement) (mm)	Evaporation (Casement) (mm)	Average Monthly Temperature (KTK) (^oC)
January	53.8	6.65	9.8	1.6
February	47.4	11.73	17.5	2.07
March	50.6	35.68	51.69	5.23
April	29.2	58	84.06	8.36
May	33.8	76.14	107.97	10.5
June	38.6	89.99	123.42	14.82
July	84.6	78.8	114.4	15.09
August	32.4	68.04	97.55	13.64
September	122	45.01	63.95	13.01
October	53.4	27.52	39.03	9.84
November	92.2	10.75	14.97	4.7
December	24	4.24	6.12	-0.01
Total	**662**	**512.55**	**730.46**	

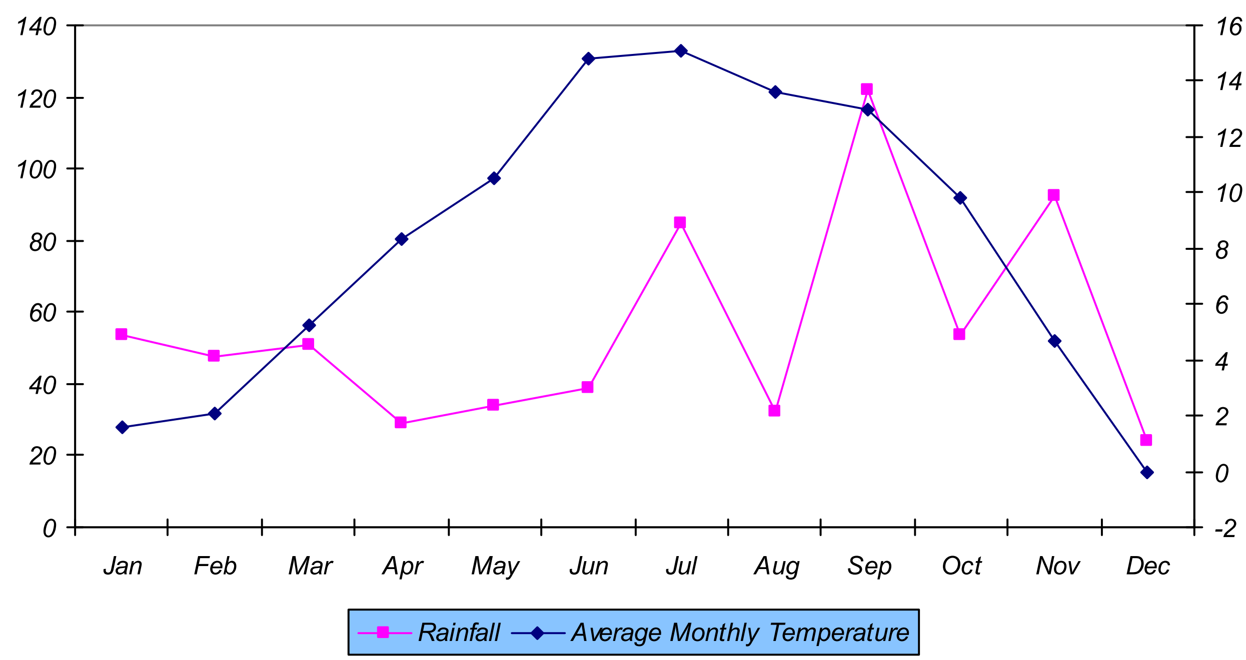


Figure 5.18. 2010 Rainfall and Temperature

6. Emissions

6.1. Landfill Gas Quantities

A landfill gas management plan was submitted to the Agency on the 12th November 2002. The plan contained a review on the controls on landfill gas, migration from the site and a gas prediction model.

Irish Power Systems installed a gas collection system in 2003. This consisted of a gas utilisation plant and an enclosed gas flare. The enclosed gas flare was put into operation in October 2003 and the gas utilisation plant was commissioned and opened in March 2004.

As part of the capping works, Kildare County Council installed a new gas collection system. This included the installation of 47 1 metre diameter wells for increased gas capture. The new collection system is connected into the enclosed flare. The capping works were completed in mid 2009 and flaring recommenced at the start of June 2009. Gas quantities at the site are now insufficient to power the gas utilisation plant.

Total landfill gas generation for 2010 was estimated at 1.289×10^7 m^3 using LandGem. Given that the waste records for the site are not complete only a very rough estimate can be made of potential gas generation.
Full emissions data is contained in the PRTR report. It should be noted that the enclosed flare onsite is now oversize for the gas volumes being produced. A landfill gas pumping trial is scheduled for 2011 to gauge the gas generation potential. The results of the trial will be used to purchase a flare of more appropriate size.

Odour Monitoring Ireland was engaged to carry out the monitoring of emissions from the flare stack. All parameters were within the emission limit values specified in Schedule C.4 of the waste licence. It was also noted that the landfill gas flare is achieving a methane destruction efficiency of greater than 99%. The full report is included in Appendix III.

6.2. Leachate Quantities

The leachate produced onsite is discharged, via a leachate rising main, to the Kilcullen sewerage scheme. The Kilcullen sewerage scheme is linked, via a leachate rising main, to Osberstown WWTP. The leachate is pumped through a methane stripping plant prior to discharge. The leachate system is now fully automated as of March 2009.

The volumes removed from the site monthly are presented in Table 6.2.

Table 6.1. Quantities of Leachate Removed from Site 2010

Month	Quantity m^3	Month	Quantity m^3
January	900	**July**	698
February	831	**August**	287
March	241	**September**	853
April	No records	**October**	587
May	187	**November**	1279
June	199	**December**	688
		Total	**6,750**

6.3. Indirect Emissions to Groundwater

Volumes of rainfall entering Phase 1 have been minimised in the past five years following the installation of a capping system, comprising at least 1m of boulder clay and 300mm of topsoil, and the directing of the surface water away from the waste body. Since then there has been a significant decrease in the volume of leachate being generated, from an estimated 66,260m^3 per annum in 1997 (based on long-term monthly mean rainfall values) to 2,219 m^3 per annum in 2010. Groundwater quality beneath and down-gradient of the site is being closely monitored to assess trends.

The following section sets out a water balance calculation for the site as a whole. However, it is important to state at the outset the assumptions being used in these calculations:

- Waste placed in Phase 1 of Silliot Hill landfill was deposited in a disused quarry. This area did not receive an artificial lining system; with the result that leachate can enter the local groundwater. Leachate generated from all areas of the facility is collected in the leachate collection system and discharged to Osberstown WWTP for treatment. It has therefore been assumed for the purposes of these calculations that indirect emissions to groundwater are generated only from Phase 1 of the landfill.

The calculated volume of leachate generated from Phase 1 in 2010 has been estimated at 2,981m3. 6,750m3 was collected from the lined portion of the site and discharged to Osberstown WWTP for treatment. In the unlined area the leachate dilutes and disperses in the subsurface environment.

6.4. Monthly Water Balance Calculations

The monthly water balance calculations have been calculated as outlined in Appendix III. The results are summarised in Table 6.3. The predicted amount of leachate can be compared with the actual amount removed from site each month.

Water balance calculations were carried out for the different elements of the facility, as follows:

- Phase 1 – unlined portion of landfill
- Phase 2 – lined portion of landfill
- Waste Transfer Station
- Civic Amenity Facility
- Other; septic tank etc.

6.4.1. Phase 1 – Unlined Portion of Landfill

Phase 1 of the landfill relies on the dilute and disperse method for dealing with leachate. The area received a final cap in 1997. Recent augmentation works to improve the clay cap were completed mid-2008. The water balance calculations carried out for Phase 1 assumed that 10% of incident rainfall percolated through this final cap into the waste body. Potential evapotranspiration is also taken into account.

6.4.2. Phase 2 – Lined Portion of Landfill

Phase 2 of the landfill accepted waste from October 1997 to March 2002. The cells received a 300mm intermediate cap of clay following their closure. They received a final cap during 2007 and 2008. The water balance calculation for this area assumed that 10% of the incident rainfall percolated through the synthetic cap into the waste body. All of this leachate was collected in the lined cells and pumped to the lagoon, prior to discharge to the Kilcullen sewerage system. Potential evaporation was taken into account.

6.4.3. Waste Transfer Station

Runoff from the floor area of the waste transfer station is collected into the leachate collection system. The leachate is collected in a pump sump and is pumped to the lagoon. Rainwater is collected from the roof of the transfer station and directed into rainwater collection tanks.

6.4.4. Civic Amenity Centre

All rainfall incidents on the civic amenity area are directed to a soak pit located at the northern corner of the facility and therefore does not affect leachate levels.

6.4.5. Sludge Treatment Facility

Leachate is not generated by the activities associated with the composting facility, which was inactive for the 2010 monitoring period.

6.4.6. Leachate Volumes

Table 6.3 outlines the predicted and actual volumes of leachate generated at the facility

Table 6.2. Leachate Volumes for 2010

Location	**Leachate Generated (m^3)**
Phase 1 Landfill Area	2981
Phase 2 Landfill Area	906
Waste Transfer Station	924
Total Predicted Volume of Leachate (Excluding Phase 1)	**2,219 (2,981)**
Predicted Total Volume of Leachate Removed	**2,219**

The volume of leachate removed in 2010, 6,750m^3, is compared to 2,219m^3 (predicted volume of leachate less that predicted for Phase 1). This is a difference of 4,531m3. This may be due to the pumping of perched water from the unlined portion of the site which was discharged to the leachate treatment plant.

6.5. Site Development Works during 2010

There was no development onsite during 2010

6.6. Proposed Development Works for 2011

- Purchase and installation of a new enclosed flare capable of operating at low gas quality and quantity.

6.6.1. Landfill Site Restoration

The restoration plan for the entire site is as follows:

- Phase 1B
  No further restoration of this area is planned,

- Phase 1A
  No further restoration of this area is planned,

- Phase 2
  No further restoration of this area is planned

7. Environmental Targets

In compliance with Condition 2.3. of the waste licence an Environmental Management Programme (EMP) has been established for the facility. The EMP includes the timescale for achieving the Objectives and Targets and the designation of responsibility for achieving the Objectives and Targets.

1. Increase the throughput of domestic customers where possible at the Civic Amenity site.

2. Increase awareness in recycling by more advertising and pamphlets.

3. Continue the School Tour Programme and increase numbers, where possible.

4. Continue efforts to source new markets for recyclable products.

5. Build a garden made from recyclable materials for display purposes.

6. Increase recycling rates, where possible.

7. To endeavour to reduce energy consumption.

8. Procurement and installation of a new enclosed, low calorific LFG flare to facilitate more efficient management of decreasing gas quantity and quality.

9. Minimisation of gas migration, especially along the southern boundary of the site.

Table 7.1. Objectives and Targets 2011

Objective/Target	Progress during 2010
Increase the throughput of domestic customers where possible	On-going
Increase awareness in recycling by more advertising and pamphlets	On-going
Continue the School Tour Programme and increase numbers, where possible	On-going
Continue efforts to source new markets for recyclable products	On-going
Build a garden made from recyclable materials for display purposes	Postponed due to lack of funding
Increase recycling rates, where possible	On-going
To endeavour to reduce energy consumption.	On-going
Procurement and installation of a new enclosed, low calorific LFG flare	Pumping trial to be carried out
Minimisation of gas migration	This will be achieved in tandem with Targets 8 & 10

7.2. Site Procedures & Forms

There has been no change to the forms used on-site, as provided in the 2004 AER.

8. Miscellaneous

8.1. Energy Consumption

The figures for energy use in 2010 are as follows:

- Electricity: 175,000 kWh (approximate)
- Fuel: 12,000 litres (approximate)
- Water: 1,000 m^3 (approximate)

8.2. Incidents and Complaints Summary

The facility manager records all site incidents and complaints on a register, which is held at the site office. The facility manager reported 12 incidents of breaches of the landfill gas trigger levels to the Agency. No landfill gas has been detected in the onsite buildings in 2010.

No complaints were received from persons regarding the facility in 2010.

8.3. Financial Provision

As part of the waste licence for the facility, Kildare County Council pays an annual contribution of €21,669 towards the cost of monitoring the facility.

8.3. Management & Staffing Structure

The management and staffing structure of the facility has been included in Appendix IV.

Appendix I

Drawing

Appendix II

Monitoring Results

Monitoring Location	Jan 2010			Feb 2010			Mar 2010		
	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)
G9s	0.0	0.0	20.7	0.0	0.8	19.5	0.0	1.4	17.7
G10s	0.0	0.1	20.7	0.0	0.0	19.2	0.0	0.0	19.1
G29	0.0	7.1	3.4	0.0	4.5	13.1	0.0	5.6	12.8
G59	0.0	2.1	19.6	0.0	1.0	18.3	0.0	1.4	18.1
G60	Tap Broken			Tap Broken			Tap Broken		
G61	0.0	4.7	17.2	0.0	10.6	8.7	0.0	11.9	9.3
G65	0.0	2.2	19.4	0.0	6.2	12.9	0.0	5.4	13
G66	0.1	8.0	0.7	0.1	7.5	1.2	0.1	7.4	0.4
G67	0.0	3.5	11.8	0.0	4.8	10.0	0.0	5.2	10.5
G71	0.0	1.0	19.1	0.0	0.8	18.9	0.0	0.7	18.5
G72	Missed			0.0	0.7	18.9	0.0	0.7	18.5
G75	3.9	16.2	7.7	0.0	7.4	10.9	0.0	8.6	11.1
G77	0.2	4.0	19.1	0.0	1.5	18.3	0.0	1.8	18.2
G78	Tap Broken			Tap Broken			Tap Broken		
G79	0.0	0.7	20.0	0.0	1.9	16.7	0.0	2.3	16.7
G80	0.0	1.7	8.3	0.0	2.5	14.0	0.0	2.4	13.8
G81	0.0	6.4	11.4	0.0	5.0	13.9	0.0	5.2	14.6
G82	0.0	0.2	20.6	0.0	0.5	19.1	0.0	0.8	18.2
G100	0.0	0.6	18.0	0.0	0.6	18.4	0.0	0.8	17.3
G101	0.0	0.2	20.6	0.0	0.0	19.1	0.0	5.9	8.3
G102	0.0	0.7	20.3	0.0	0.2	19.0	0.0	0.7	19.9
G103	0.0	0.1	20.6	17.2	16.9	2.3	25.5	23.8	1.0
G104d	34.9	18.1	2.3	32.6	16.2	4.0	33.6	15.1	1.3
G104s	35.8	11.3	0.0	26.8	12.2	1.5	30.7	12.6	0.5
G105	0.0	0.1	20.6	37.2	20.1	1.2	42.4	29.3	0.5
G106d	4.1	12.6	8.2	3.6	14.3	6.2	4.9	13.6	5.0
G108	Flooded			Flooded			Flooded		
G109s	0.4	0.7	20.1	0.5	1.0	18.7	18.8	22.6	1.0
G110	0.0	1.3	20.1	0.0	0.9	18.7	0.0	9.0	9.6
G111	0.0	2.4	17.9	0.0	3.2	15.2	0.0	4.4	14.3
G112	0.0	0.4	20.5	0.0	0.5	18.8	0.0	2.6	17.1
G113	0.0	0.1	20.7	0.0	0.5	19.2	0.0	4.0	12.9
G114s	0.0	0.0	20.7	0.0	0.0	20.5	No Access		
G115-07	0.0	0.0	20.7	0.0	0.0	19.1	0.0	0.0	19.1
G200-07	0.0	0.0	20.8	0.0	0.0	20.2	0.0	0.6	18.3
G201-07	0.0	0.1	20.7	0.0	0.1	20.2	0.0	0.0	18.9
G300-07	0.0	0.3	20.5	0.0	0.0	20.1	0.0	0.0	19
G301-07	0.0	0.6	19.5	0.0	0.2	20.1	0.0	0.2	18.8
G302-07	0.0	1.1	15.1	0.0	0.6	19.6	0.0	0.8	17.7
G303-07	0.0	0.5	18.8	0.0	0.4	19.2	0.0	0.6	18.2
G400-07	1.9	6.7	13.5	1.6	6.4	13.2	1.4	12.7	4.9
G401-07	0.0	0.9	19.9	0.0	1.2	17.9	0.0	1.5	17.4

Monitoring Location	Apr 2010			May 2010			Jun 2010		
	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)
G9s	0	1.3	17.2	0	1.6	17.2	0	1.4	17.7
G10s	0	0	19.1	0	0	19.2	0	0	19.1
G29	0	6.3	10.6	0	4.0	15.5	0	5.6	12.8
G59	0	8.8	9.9	0	13.1	4.1	0	1.4	18.1
G60	Tap Broken			Tap Broken			Tap Broken		
G61	0	10.7	10.9	0	12.8	8.4	0	11.9	9.3
G65	0	7.2	9.5	0.2	7.1	11.2	0	5.4	13
G66	0.1	8.6	1.1	0.1	8.2	1.3	0.1	7.4	0.4
G67	0	5.4	12.6	0	3.9	14.8	0	5.2	10.5
G71	0.0	1.0	19.2	0	1.8	15.9	0	0.7	18.5
G72	0	1.9	17.8	0	0	19.4	0	0.7	18.4
G75	5.7	17.9	0.4	0.3	9.8	7.3	0	8.6	11.1
G77	0.1	5.3	17.9	0	2.1	17.0	0	1.8	18.2
G78	Tap Broken			Tap Broken			Tap Broken		
G79	0	1.9	14.8	0	1.1	17.2	0	2.3	16.7
G80	0	4.8	9.4	0	3.9	11.4	0	2.4	13.8
G81	0	6.6	11.1	0	6.1	12.4	0	5.2	14.6
G82	0	0.7	18.9	0	0.7	18.3	0	0.8	18.2
G100	0	0.8	17.7	0	1.1	15.2	0	0.8	15.9
G101	0	5.9	8.1	0	0.2	18.8	0	0.1	19.2
G102	0	0.6	18.7	0	0.4	18.7	0	0.5	18.8
G103	24.6	21.4	1.0	0	0.2	19	0	0.2	19
G104d	13.6	7.7	11.0	27.2	14.3	3.2	32.4	15	1.6
G104s	18.3	8.9	7.0	21.9	12.8	1.8	26.8	14.9	0.2
G105	Flooded			Flooded					
G106d	4.1	11.6	5.4	2	10	6.9	1.1	9.1	7.8
G108	Flooded			Flooded			Flooded		
G109s	0	0.5	19.6	0	0	19.3	0	0.9	14.3
G110	0	0.1	19.3	0	1.3	18.1	0	0.9	18.8
G111	0	1.7	16.8	0	2.1	16.3	0	1.9	17.6
G112	0	1.1	17.4	0	0.6	18.5	0	0.7	19
G113	0	0.5	18.1	0	0.5	18.7	0	0.4	19
G114s	0	1.9	16.6	0	1.5	16.5	0	0.7	18.3
G115-07	0	3.1	13.1	0	0.4	18	0	0	19.1
G200-07	0	0	19.6	0	0	18.8	0	0.6	18.3
G201-07	0	0	19.1	0	0	18.8	0	0	18.9
G300-07	0	0	19.2	0	0.1	18.9	0	0	19
G301-07	0	0.3	19.0	0	0.4	18.3	0	0.2	18.8
G302-07	0	0	19.3	0	0	19	0	0.8	17.7
G303-07	0	0.4	19.7	0	0.8	16.4	0	0.6	18.2
G400-07	2.0	7.3	12.9	2.1	6.4	13.2	1.4	12.7	4.9
G401-07	0	0.6	19.6	0	0.9	19.1	0	1.5	17.4

Monitoring Location	July 2010			August 2010			September 2010		
	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)
G9s	0	0	17.2	0	0	17.2	0	0	17.7
G10s	No Access			0	0	19.2	0	0	19.1
G29	0	8.7	10.6	0	4.2	15.5	0	5.7	12.8
G59	0	7.2	11.3	0	5.1	15.4	0	1.3	18.1
G60	Tap Broken			Tap Broken			Tap Broken		
G61	0	10.9	10.9	0	13	8.4	0	11.4	7.5
G65	0	7.4	9.5	0.2	7.1	11.2	0	5.4	13
G66	0.2	8.8	1.1	0.2	8.2	1.3	0.1	7.4	0.4
G67	0	6.4	12.6	0	3.9	14.8	0	5.2	10.5
G71	0	1.9	12	0	1.8	15.9	0	0.7	18.5
G72	0	1.9	17.8	0	0	19.4	0	0.9	18.4
G75	0	18.4	0.4	0.5	10.8	7.3	0	8.4	11.1
G77	0	12.6	11.0	0	2.6	17	0	1.8	18.2
G78	Tap Broken			Tap Broken			Tap Broken		
G79	0	1.9	14.8	0	1.1	17.2	0	2.3	16.7
G80	0	4.8	9.4	0	3.9	11.4	0	2.4	13.8
G81	0	6.6	11.1	0	6.1	12.4	0	5.2	14.6
G82	0	0.7	18.9	0	0.7	18.3	0	0.8	18.2
G100	0	0.8	15.7	0	1.1	15.2	0	0.8	15.9
G101	0	0.9	18.1	0	0.2	18.8	0	0.1	19.2
G102	0	0.6	18.7	0	0.4	18.7	0	0.5	18.8
G103	6.4	6.1	14.7	0	0.3	19	0	0.3	19
G104d	14.6	7.8	11.0	27.1	14.2	3.2	32.6	15.1	1.6
G104s	18.2	9.5	7.0	22.2	12.9	1.8	27.8	15	0.2
G105	Flooded			29.3	19	3.6	Flooded		
G106d	4.7	12.6	5.4	2	9.9	7	1.2	10.1	6.8
G108	Flooded			Flooded			Flooded		
G109s	7.6	9.3	9.6	0	0	19.3	0	6.8	14.3
G110	0	0.1	19.3	0	1.3	18.1	0	0.9	18.8
G111	0	2.2	16.8	0	2.3	16.3	0	2	17.6
G112	0	1.5	17.4	0	0.8	18.5	0	0.7	19
G113	0	1.0	18.1	0	0.4	18.7	0	0.2	19
G114s	0	2.3	16.6	0	2.2	16.5	0	1.3	18.3
G115-07	0	3.1	13.1	0	0.4	18	0	1.6	14.9
G200-07	0	0	19.6	0	0	18.8	0	0.6	18.3
G201-07	0	0	19.1	0	0	18.8	0	0	18.9
G300-07	0	0	19.2	0	0.1	18.9	0	0	19
G301-07	0	0.3	19.0	0	0.4	18.3	0	0.2	18.8
G302-07	0	0	19.3	0	0	19	0	0.8	17.7
G303-07	0	0.4	19.7	0	0.8	16.4	0	0.6	18.2
G400-07	2.8	8.3	10.4	2	5.8	13.4	1.2	12.8	4.8
G401-07	0	3.6	15.5	0.2	0.6	19.7	0	1.5	17.4

Monitoring Location	Oct 2010			Nov 2010			Dec 2010		
	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)
G9s	0	0	17.2	0	0	17.2	0	0	17.7
G10s	No Access			0	0	19.2	0	0	19.1
G29	0	8.7	10.6	0	4.2	15.5	0	5.7	12.8
G59	0	7.2	11.3	0	5.1	15.4	0	1.3	18.1
G60	Tap Broken			Tap Broken			Tap Broken		
G61	0	10.9	10.9	0	13	8.4	0	11.4	7.5
G65	0	7.4	9.5	0.2	7.1	11.2	0	5.4	13
G66	0.2	8.8	1.1	0.2	8.2	1.3	0.1	7.4	0.4
G67	0	6.4	12.6	0	3.9	14.8	0	5.2	10.5
G71	0	1.9	12	0	1.8	15.9	0	0.7	18.5
G72	0	1.9	17.8	0	0	19.4	0	0.9	18.4
G75	0	18.4	0.4	0.5	10.8	7.3	0	8.4	11.1
G77	0	12.6	11.0	0	2.6	17	0	1.8	18.2
G78	Tap Broken			Tap Broken			Tap Broken		
G79	0	1.9	14.8	0	1.1	17.2	0	2.3	16.7
G80	0	4.8	9.4	0	3.9	11.4	0	2.4	13.8
G81	0	6.6	11.1	0	6.1	12.4	0	5.2	14.6
G82	0	0.7	18.9	0	0.7	18.3	0	0.8	18.2
G100	0	0.8	15.7	0	1.1	15.2	0	0.8	15.9
G101	0	0.9	18.1	0	0.2	18.8	0	0.1	19.2
G102	0	0.6	18.7	0	0.4	18.7	0	0.5	18.8
G103	6.4	6.1	14.7	0	0.3	19	0	0.3	19
G104d	14.6	7.8	11.0	27.1	14.2	3.2	32.6	15.1	1.6
G104s	18.2	9.5	7.0	22.2	12.9	1.8	27.8	15	0.2
G105	Flooded			29.3	19	3.6	Flooded		
G106d	4.7	12.6	5.4	2	9.9	7	1.2	10.1	6.8
G108	Flooded			Flooded			Flooded		
G109s	7.6	9.3	9.6	0	0	19.3	0	6.8	14.3
G110	0	0.1	19.3	0	1.3	18.1	0	0.9	18.8
G111	0	2.2	16.8	0	2.3	16.3	0	2	17.6
G112	0	1.5	17.4	0	0.8	18.5	0	0.7	19
G113	0	1.0	18.1	0	0.4	18.7	0	0.2	19
G114s	0	2.3	16.6	0	2.2	16.5	0	1.3	18.3
G115-07	0	3.1	13.1	0	0.4	18	0	1.6	14.9
G200-07	0	0	19.6	0	0	18.8	0	0.6	18.3
G201-07	0	0	19.1	0	0	18.8	0	0	18.9
G300-07	0	0	19.2	0	0.1	18.9	0	0	19
G301-07	0	0.3	19.0	0	0.4	18.3	0	0.2	18.8
G302-07	0	0	19.3	0	0	19	0	0.8	17.7
G303-07	0	0.4	19.7	0	0.8	16.4	0	0.6	18.2
G400-07	2.8	8.3	10.4	2	5.8	13.4	1.2	12.8	4.8
G401-07	0	3.6	15.5	0.2	0.6	19.7	0	1.5	17.4

Parameter	SW 1	SW 2	SW 3	SW 4	SW 6	SW 7	MAC
pH (pH units)	8	8.1	7.7	6.5	8	8.3	5.5 – 8.8
Conductivity @ 25°C (mS/cm)	1.17	0.89	0.69	0.39	0.34	0.39	1
Ammoniacal Nitrogen (mg/l)	1.25	0.091	0.013	2.4	0.066	<0.01	0.23
DO (% sat)	97.3	80.4	65.4	9.5	88.5	NR	No Abnormal Change
COD (mg/l)	10	8	<5	60	7	6	40
BOD (mg/l)	<2	<2	<2	17	3	<2	5
Chloride (mg/l Cl)	97	70	15	20	12	15	250
Total Suspended Solids (mg/l)	3	12	222	2985	6	<2	50
Temperature (°C)	2.0	4.8	3.4	2.2	4.4	NR	No Abnormal Change

Parameter	SW 1	SW 2	SW 3	SW 4	SW 6	SW 7	MAC
pH (pH units)	8.15	8.09	7.9	No Sample	8.14	8.15	5.5 – 8.8
Conductivity @ 25°C (mS/cm)	1.21	0.822	0.648		0.269	0.278	1
Ammoniacal Nitrogen (mg/l)	0.276	<0.2	<0.2		<0.2	<0.2	0.23
COD (mg/l)	26.1	17.4	1540		13.6	13.4	40
BOD (mg/l)	1.06	<1	13.5		<1	<1	5
Chloride (mg/l Cl)	162	80.6	16.3		9.9	11.4	250
Total Suspended Solids (mg/l)	8.5	22.5	2320		2	<2	50

Parameter	SW 1	SW 2	SW 3	SW 4	SW 6	SW 7	MAC
pH (pH units)	8.39	8.4	8.18	No Sample	8.41	No Sample	5.5 – 8.8
Conductivity @ 20°C (mS/cm)	0.747	0.662	0.517		0.258		1
Ammoniacal Nitrogen (mg/l)	<0.2	0.287	0.382		<0.2		0.23
COD (mg/l)	32.4	48.5	214		36.1		40
BOD (mg/l)	1.76	1.96	4.08		1.08		5
Chloride (mg/l Cl)	74.5	55.2	11		9		250
Total Suspended Solids (mg/l)	21	8.5	296		59		50

Parameter	BH 3	BH 4-07	BH 9D	BH 11 D	KTK 20	GWR 1	GWR 2	GWR 3	IGV
pH (pH units)	7	7	7	7.4	7.1	7.2	7.1	7	**6.5 -9.5**
Conductivity @25 ^{o}C (mS/cm)	0.73	3.38	1.07	0.68	0.74	0.75	0.71	0.76	**1**
Ammoniacal Nitrogen (mg/l)	1.73	185.5	0.02	0.03	0.07	<0.01	<0.01	<0.01	**0.12**
Iron (µg/l)	533	442	124	253	207	130.8	89.7	36.4	**200**
Potassium	0.89	77.26	6.47	0.85	1.08	1.10	0.57	0.68	**5**
Sodium	7.7	315.7	49.9	7.56	13.2	24.4	7.04	7.22	**150**
Chloride	24	166.5	86.8	14.6	14.9	43.75	24.5	12.97	**30**
TON (mg/l N)	1.16	0.54	10.1	5.55	<0.3	2.36	6.18	2.85	**NAC**
Total Phenols	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
TOC	NT	NT	NT	NT	NT	NT	NT	NT	**NAC**
Total Coliforms (cfu/100ml)	8	37	16	44	9	51	123	4	**<1**
Feacal Coliforms (cfu/100ml)	0	0	0	0	2	0	12	0	**<1**
Temperature (^{o}C)	10.5 8	16.68	9.06	9.5	8.6	10.06	10.37	9.5	**25**
DO (% sat)	80.1	40.1	60.7	68.3	NR	70.8	61.3	53.9	**NAC**

Parameter	BH 1	BH 2	BH 3	BH 4-07	BH 9D	BH 11 D	GWR 1	GWR 2	GWR 3	MAC
pH (pH units)	7.58	7.54	7.32	7.58	7.51	8.08	7.68	7.77	7.27	**6.5 - 9.5**
Conductivity @25 °C (mS/cm)	0.822	0.575	0.644	3.55	1.06	0.598	0.669	0.66	0.718	**1**
Ammoniacal Nitrogen (mg/l)	<0.2	1.01	2.23	226	<0.2	<0.2	<0.2	<0.2	<0.2	**0.12**
Iron (mg/l)	<0.019	5.58	0.508	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	**0.2**
Potassium	<2.34	4.37	<2.04	120	8.36	<2.34	2.43	<2.34	<2.34	**5**
Sodium	25	27.2	9.58	459	66	10.6	13.3	9.19	9.75	**150**
Chloride	71.5	14.8	20.1	340	135	13.7	29.3	21.6	12.6	**30**
TON (mg/l N)	3.2	<0.1	0.146	<0.1	9	5.28	2.58	3.63	0.98	**NAC**
Total Phenols	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
TOC	4.02	5.93	3.29	66.9	6.29	3.31	<3	<3	3.24	**NAC**
Total Coliforms (cfu/100ml)	0	6	0	0	25	29000	210000	1500	9000	**<1**
Faecal Coliforms (cfu/100ml)	0	0	0	0	0	0	10000	1500	0	**<1**
Temperature (°C)	NR	NR	NR	NR	NR	NR	NR	NR	NR	**25**
DO (% sat)	NR	NR	NR	NR	NR	NR	NR	NR	NR	**NAC**

Parameter	BH1	BH3	BH4-07	BH9D	GWR 2	GWR 3	IGV
pH (pH units)	8.21	8.39	8.31	8.14	8.39	7.65	**6.5-9.5**
Conductivity @ 20 °C (mS/cm)	0.813	0.634	3.67	1.14	0.383	0.69	**1**
Ammonical Nitrogen (N)	0.247	2.47	243	0.21	<0.2	<0.2	**0.12**
Iron	<0.019	0.133	<0.019	<0.019	<0.019	<0.019	**200**
Potassium	<2.34	<2.34	114	10.1	3.67	<2.34	**5**
Sodium	25.3	9.63	376	74.5	4.26	8.49	**150**
Chloride	69.8	20	283	162	9.3	11.3	**30**
Total Oxidised Nitrogen (N)	2.77	<0.1	<0.1	8.4	1.08	1.42	**No abnormal change**
Phenols	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	**N/A**
Total Organic Carbon	3.2	4.57	391	<3	6.79	4.04	**No abnormal change**
Faecal Coliforms (cfu/100ml)	<1	<1	<1	<1	54100	<1	**<1**
Total Coliforms (cfu/100m)	<1	<1	500	62	54100	<1	**<1**
Dissolved Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.001**
Total Solids	577	476	2450	926	1980	1430	**1000**
Total Chromium (µg/l)	5.86	6.8	50.3	6.57	4.05	17.6	**0.03**
Total Phosphorous (µg/l)	81.1	<20	599	166	668	249	**0.03**
Dissolved Cadmium (µg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**200**
Dissolved Copper (µg/l)	0.887	<0.85	3.78	1.52	1.4	0.986	**30**
Dissolved Lead (µg/l)	0.06	<0.02	0.11	0.029	0.02	<0.02	**10**
Dissolved Magnesium	12.5	14.5	21.2	10.4	7.12	10.4	**50**
Dissolved Manganese (µg/l)	3.07	423	117	27.4	114	9.84	**50**
Dissolved Zinc (µg/l)	1.67	<0.41	4.79	1.49	0.709	1.82	**100**
Fluoride	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**1**
Sulphate	27.9	<3	6.2	70.7	6.4	14.1	**200**
Total Cyanide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	**0.01**
Total Alkalinity ($CaCO_3$)	150	180	1740	150	360	520	**200**

Parameter	BH1	BH3	BH4-07	BH9D	IGV
pH (pH units)	8.27	8.31	8.86	7.83	**6.5-9.5**
Conductivity @ 20 °C (mS/cm)	0.792	0.635	3.51	1.25	**1**
Ammonical Nitrogen (N)	0.884	2.2	233	<0.2	**0.12**
Iron	<0.019	1.88	<0.019	<0.019	**200**
Potassium	<2.34	<2.34	110	10.2	**5**
Sodium	27.3	9.66	329	95.8	**150**
Chloride	69.3	21.5	327	195	**30**
Total Oxidised Nitrogen (N)	1.33	<0.1	0.111	7.5	**No abnormal change**
Phenols	0.06	<0.015	<0.015	<0.015	**N/A**
Total Organic Carbon	4.16	3.67	77.3	6.69	**No abnormal change**
Faecal Coliforms (cfu/100ml)	1	<1	<1	900	**<1**
Total Coliforms (cfu/100m)	5	<1	<1	900	**<1**

Parameter	PW 2-09	PW 4	PW 9	PW 11	MAC
pH (pH units)	7.2	7.5	7.2	7.2	**6.5 -9.5**
Conductivity @25 °C (mS/cm)	0.78	0.67	0.71	0.39	**1**
Ammoniacal Nitrogen (mg/l)	<0.01	<0.01	0.01	0.07	**0.12**
Iron (µg/l)	<0.66	<0.66	<0.66	171.2	**200**
Potassium	1.56	0.14	0.34	3.11	**5**
Sodium	22.08	170.1	7.38	12.58	**150**
Chloride	38	16	12.75	14	**30**
TON (mg/l N)	10.02	5.63	1.32	<0.28	**NAC**
Total Phenols	<0.1	<0.1	<0.1	<0.1	**-**
TOC	NT	NT	NT	NT	**NAC**
Total Coliforms (cfu/100ml)	0	41	0	181	**<1**
Feacal Coliforms (cfu/100ml)	0	0	0	19	**<1**
Temperature (°C)	NR	13.68	10.1	7.68	**25**
DO (% sat)	72.9	72.5	75.5	NR	**NAC**

Parameter	PW 2-09	PW 4	PW 11	MAC
pH (pH units)	7.85	8.06	7.81	**6.5 -9.5**
Conductivity @25 ^{o}C (mS/cm)	0.668	0.594	0.454	**1**
Ammoniacal Nitrogen (mg/l N)	<0.2	<0.2	<0.2	**0.12**
Iron (mg/l)	<0.019	<0.019	<0.019	**0.2**
Potassium (mg/l)	<2.34	<2.34	5.48	**5**
Sodium (mg/l)	19.8	12.6	9.38	**150**
Chloride (mg/l)	27.2	17.7	10.5	**30**
TON (mg/l N)	10.2	5.44	0.785	**NAC**
Total Phenols (mg/l)	<0.1	<0.1	<0.1	**-**
TOC (mg/l)	<3	<3	5.13	**NAC**
Total Coliforms (cfu/100ml)	0	6	10000	**<1**
Feacal Coliforms (cfu/100ml)	0	3	0	**<1**
Temperature (^{o}C)	NR	NR	NR	**25**
DO (% sat)	NR	NR	NR	**NAC**

Parameter	PW2-09	PW4	IGV
pH (pH units)	8.43	8.52	**6.5 – 9.5**
Conductivity (mS/cm)	0.66	0.609	**1**
Ammonical Nitrogen (N)	0.252	<0.2	**0.12**
Iron	<0.019	<0.019	**200**
Potassium	<2.34	2.54	**5**
Sodium	19.2	11.3	**150**
Chloride	25	15.2	**30**
Total Oxidised Nitrogen (N)	10.5	4.5	**No abnormal change**
Phenols	<0.015	<0.015	**N/A**
Total Organic Carbon	<3	<3	**No abnormal change**
Faecal Coliforms (cfu/100ml)	2	212	**<1**
Total Coliforms (cfu/100m)	11	240	**<1**
Dissolved Mercury (µg/l)	<0.01	<0.01	**0.001**
Total Chromium (µg/l)	6.13	7.92	**0.03**
Total Phosphorous (µg/l)	<20	<20	**0.03**
Dissolved Cadmium (µg/l)	<0.1	<0.1	
Dissolved Copper (µg/l)	14.5	16.3	**30**
Dissolved Lead (µg/l)	0.506	0.342	**10**
Dissolved Magnesium	10.7	16.6	**50**
Dissolved Manganese (µg/l)	0.077	0.26	**50**
Dissolved Zinc (µg/l)	17.2	17	**100**
Fluoride	<0.5	<0.5	**1**
Sulphate	38.3	11.3	**200**
Total Cyanide	<0.05	<0.05	**0.01**
Total Alkalinity ($CaCO_3$)	105	135	**200**

Parameter	PW 2-09	PW 4	PW 11	IGV
pH (pH units)	8.11	8.3	8.51	**6.5 – 9.5**
Conductivity (mS/cm)	0.709	0.585	0.406	**1**
Ammonical Nitrogen (N)	<0.2	0.753	<0.2	**0.12**
Iron	<0.019	<0.019	<0.019	**200**
Potassium	<2.34	<2.34	4.82	**5**
Sodium	19.2	8.06	7.33	**150**
Chloride	28.3	14.3	10.7	**30**
Total Oxidised Nitrogen (N)	10.5	5.58	3.44	**No abnormal change**
Phenols	<0.015	<0.015	<0.015	**N/A**
Total Organic Carbon	<3	3.27	3.85	**No abnormal change**
Faecal Coliforms (cfu/100ml)	<1	1	21	**<1**
Total Coliforms (cfu/100m)	<1	1	241	**<1**

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PM_{10} MONITORING AT THREE SAMPLING LOCATIONS IN THE VICINITY OF SILLIOT LANDFILL SITE, SILLIOT HILL, AND BROWNSTOWN, CO. KILDARE

PREPARED BY ODOUR MONITORING IRELAND ON BEHALF OF KILDARE COUNTY COUNCIL

PREPARED BY:	*Dr. Brian Sheridan,*
ATTENTION:	*Ms. Claire McLaughlin*
DATE:	*08th March 2011*
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<u>Title:</u> *PM_{10} monitoring at three sampling locations in the vicinity of Silliot hill residual landfill site, Silliot hill, Brownstown, Co. Kildare.*

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<tr><td colspan="6">ODOUR monitoring IRELAND</td></tr>
</table>

PM_{10} monitoring

1. Introduction

Odour Monitoring Ireland were commissioned by Kildare County Council to undertake a PM_{10} (Particulate matter 10 μm aerodynamic diameter) monitoring program in the vicinity of Silliot Hill Residual Landfill in order to assess the potential impact to air quality in accordance with the statutory limits established by SI 271 of 2002 and Waste licence W014-01.

Due to the fact that there was no power at any of the monitoring locations PM1 to PM3, PM_{10} monitoring was performed using a battery operated gravimetric PM_{10} monitor.

The results presented herein demonstrate that PM_{10} air quality is average to good at all monitoring locations PM1 to PM3 (i.e. Air Quality Index rating, www.epa.ie).

Monitoring was performed between 13th and 15th December 2010.

It is concluded that PM_{10} concentrations were below the 50 $\mu g/m^3$ impact criterion for the residual landfill site.

2. Materials and methods

This section will describe the materials and methods used throughout the study

2.1 Particulate matter (PM_{10}) monitoring

Major sources of particulates include industrial/residential combustion and processing, energy generation, vehicular emissions and construction projects. The particulate matter created by these processes is responsible for many adverse environmental conditions including reduced visibility, contamination and soiling, but also recognised as a contributory factor to many respiratory medical conditions such as asthma, bronchitis and lung cancer. PM_{10} (Particulate Matter 10) refers to particulate matter with an aerodynamic diameter of 10 μm. Generally, such particulate matter remains in the air due to low deposition rates. It is the main particulate matter of concern in Europe and has existing air quality limits. In order to obtain ambient air PM_{10} concentration levels for the Silliot Hill Residual Landfill site, a battery operated gravimetric Particulate sampler (Partisol) was used. Three fixed monitoring locations (i.e. PM1 to PM3) as established under Waste licence W014-01 for the study were used to perform gravimetric monitoring over the sampling period. The monitoring locations and results are presented in Figure 4.1 and Table 2.1.

Table 2.1. *Average ambient PM_{10} concentrations for three fixed monitoring locations at the Silliot Hill Residual Landfill site.*

Monitoring locations	Sample number	Average concentration value (µg/m3)
PM1-13/12/2010	101285	12
PM2-14/12/2010	101293	10
PM3-15/12/2010	101291	17
Limit value	**SI271 of 2002**	**50**

Notes: *[1]denotes Irish and EU ambient air standard (SI 271 of 2002 and 1999/30/EC) as a 24-hour average;*

PM_{10} monitoring in Ireland is limited to continuous monitoring stations operated by the Local Authorities and the Irish EPA, mainly in large urban centres. Average 24-hour ambient air concentrations monitored in the Phoenix Park and Whitehall, respectively by Dublin Corporation are in the range of 16 $\mu g\ m^{-3}$ and 17 $\mu g\ m^{-3}$ for an annual mean in 1999. The dominant source of PM_{10} in the area appears to be HGV emissions, boilers (i.e. Home heating and Industrial heating), traffic, wind blown dust and construction activities. The average ambient PM_{10} concentrations are in the range of those monitored by Dublin Corporation.

2.2 Assessment Criteria

The EU has introduced several measures to address the issue of air quality management. In 1996, Environmental Ministers agreed a Framework Directive on ambient air quality assessment and management (Council Directive 96/62/EC). As part of the measures to improve air quality, the European Commission has adopted proposals for daughter legislation under Directive 96/62/EC. The first of these directives to be enacted, 1999/30/EC, has set limit values which replaced existing limit values under Directives 80/779/EEC, 82/884/EEC and 85/203/EEC in April 2001. The new directive, as relating to limit values for PM_{10}, is detailed in Table 2.2.

The National Air Quality Standards Regulations 2002 (S.I. No. 271 of 2002) transpose those parts of the "Framework" Directive 92/30/EC on ambient air quality assessment and management not transposed by Environment Protection Agency Act 1992 (Ambient Air Quality Assessment and Management) Regulations 1999 (S.I. No. 33 of 1999). The 2002 Regulations also transpose, in full, the 1st two "Daughter" Directives 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air and 2000/69/EC relating to limit values for benzene and carbon monoxide in ambient air.

Table 2.2. *Irish and EU Ambient Air Standard (SI 271 of 2002 and 1999/30/EC).*

Particulate Matter Stage 1	*1999/30/EC SI 271 of 2002*	*24-hour limit for protection of human health - not to be exceeded more than 35 times/year-24 hour average*	*50% until 2001 reducing linearly to 0% by 2005 for 1999/30/EC 30% from the date of entry into force of these Regulations, reducing on 1 January 2003 and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2005 for SI 271 of 2002*	*50μg/m³ PM₁₀*
		Annual limit for protection of human health-Annual	*20% until 2001 reducing linearly to 0% by 2005 for 1999/30/EC 12% from the date of entry into force of these Regulations, reducing on 1 January 2003 and every 12 moths thereafter by equal annual percentages to reach 0% by 1 January 2005*	*40μg/m³ PM₁₀*
Particulate Matter Stage 2	*1999/30/EC SI 271 of 2002*	*24-hour limit for protection of human health - not to be exceeded more than 7 times/year-24 hour average*	*To be derived from data and to be equivalent to Stage 1 limit value for 1999/30/EC Not to be exceeded more than 28 times by 1 January 2006, 21 times by 1 January 2007, 14 times by 1 January 2008, 7 times by 1 January 2009 and zero times by 1 January 2010 for SI 271 of 2002*	*50 μg/m³ PM₁₀*
		Annual limit for protection of human health-Annual	*50% until 2005 reducing linearly to 0% by 2010 for 1999/30/EC and SI 271 of 2002*	*20 μg/m³ PM₁₀*

3. Conclusions

The following conclusions were drawn during the study:

1. *Ambient air concentration levels of PM_{10} were below the statutory 24-hour average ambient air concentration level of 50 μg m^{-3} at all monitoring locations PM1 to PM3.*

Appendix III

Emissions: Water Balance & Flare Stack Testing

Estimated volume of leachate generated in Phase 1 in 2010

Month	Rainfall (mm/month)	Area (m^3)	Effective Rainfall (% of actual)	Effective Rainfall (m)	Leachate Generated (m^3/month)
January	53.8	79,000	57	0.030666	242
February	47.4	79,000	57	0.027018	213
March	50.6	79,000	57	0.028842	228
April	29.2	79,000	57	0.016644	131
May	33.8	79,000	57	0.019266	152
June	38.6	79,000	57	0.022002	174
July	84.6	79,000	57	0.048222	381
August	32.4	79,000	57	0.018468	146
September	122	79,000	57	0.06954	549
October	53.4	79,000	57	0.030438	240
November	92.2	79,000	57	0.052554	415
December	24	79,000	57	0.01368	108
Total					**2981**

Estimated volume of leachate generated in Phase 2 in 2010

Month	Rainfall (mm/month)	Area (m^2)	Effective Rainfall (% of actual)	Effective Rainfall (m)	Leachate Generated (m^3/month)
January	53.8	24,000	57	0.030666	74
February	47.4	24,000	57	0.027018	65
March	50.6	24,000	57	0.028842	69
April	29.2	24,000	57	0.016644	40
May	33.8	24,000	57	0.019266	46
June	38.6	24,000	57	0.022002	53
July	84.6	24,000	57	0.048222	116
August	32.4	24,000	57	0.018468	44
September	122	24,000	57	0.06954	167
October	53.4	24,000	57	0.030438	73
November	92.2	24,000	57	0.052554	126
December	24	24,000	57	0.01368	33
Total					**906**

Estimated volume of leachate generated in WTS in 2010

Month	Rainfall (mm/month)	Area (m^2)	Effective Rainfall (% of actual)	Effective Rainfall (m)	Leachate Generated (m^3/month)
January	53.8	2,450	57	0.030666	75
February	47.4	2,450	57	0.027018	66
March	50.6	2,450	57	0.028842	71
April	29.2	2,450	57	0.016644	41
May	33.8	2,450	57	0.019266	47
June	38.6	2,450	57	0.022002	54
July	84.6	2,450	57	0.048222	118
August	32.4	2,450	57	0.018468	45
September	122	2,450	57	0.06954	170
October	53.4	2,450	57	0.030438	74
November	92.2	2,450	57	0.052554	129
December	24	2,450	57	0.01368	34
Total					**924**

Estimated volume of leachate generated in CA in 2010

Month	Rainfall (mm/month)	Area (m^2)	Effective Rainfall (% of actual)	Effective Rainfall (m)	Leachate Generated (m^3/month)
January	53.8	1,030	57	0.030666	32
February	47.4	1,030	57	0.027018	28
March	50.6	1,030	57	0.028842	30
April	29.2	1,030	57	0.016644	17
May	33.8	1,030	57	0.019266	20
June	38.6	1,030	57	0.022002	23
July	84.6	1,030	57	0.048222	50
August	32.4	1,030	57	0.018468	19
September	122	1,030	57	0.06954	72
October	53.4	1,030	57	0.030438	31
November	92.2	1,030	57	0.052554	54
December	24	1,030	57	0.01368	14
Total					**389**

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AIR EMISSION TESTING OF ONE LANDFILL FLARE LOCATED IN SILLIOT HILL WASTE MANAGEMENT FACILITY, SILLIOT HILL, BROWNSTOWN CO. KILDARE

PREFORMED BY ODOUR MONITORING IRELAND ON BEHALF OR KILDARE COUNTY COUNCIL

PREPARED BY:	*Dr. John Casey*
ATTENTION:	*Ms. Claire McLaughlin*
REFERENCE:	*Waste licence 14-1*
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<u>Project:</u> *Air emission testing of one Landfill flare located in Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare.*

Project Number: *2010A51(1)*			***Document Reference:*** *Air emission testing of one Landfill flare located in Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare.*		
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1. Introduction

This report has been prepared by Odour Monitoring Ireland and contains the results of emission testing carried out on 1 No. Enclosed ground flare at Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare. The emission testing was carried out in compliance with the requirements of Waste licence W0014-01.

Odour Monitoring Ireland was commissioned by Ms. Claire McLaughlin, Environment Section, Kildare County Council to perform emission testing of the 1 landfill gas flare stack located within Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare. The parameters listed in Table 1.1 were monitored using the appropriate instrumentation as illustrated in Table 1.1.

***Table 1.1.** Monitored parameters and techniques for Holmestown Waste Management Facility 1 No. Enclosed flare, Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare.*

Sample location	Parameter	Analytical method
1 Landfill Flare outlet	Volumetric airflow rate & Temperature (^0C)	MGO coated K type thermocouple and PT100 Volumetric airflow rate theoretical calculated for Landfill flare.
1 Landfill Flare outlet	Oxides of nitrogen (NO_X as NO_2), Carbon monoxide (CO), Carbon dioxide (CO_2), Sulphur dioxide (SO_2), and Oxygen (O_2)	Flue gas analyser, Testo 350/454 MXL
1 Landfill Flare outlet	Total Hydrocarbons and Total non methane VOC	Portable Signal 3030PM FID with Non methane flow cutter calibrated with Propane
1 Landfill Flare outlet	TA Luft Organics	Charcoal tube/GCFID
1 Landfill Flare outlet	Hydrogen fluoride & hydrogen chloride	Impinger/Ion chromatography (IC)

This report presents details of this monitoring programme. This environmental monitoring was carried out Dr. John Casey, Odour Monitoring Ireland on the 15th January 2010. Methodology, Results, Discussion and Conclusions are presented herein.

2. Materials and Methods

This section provides brief details of the methodology employed to perform emission testing of one landfill flare stack located in Silliot Hill Waste Management facility.

2.1 Volumetric flow rate and temperature measurement

The volumetric flow rate of the landfill flare was determined from theoretically calculated total volumetric flow rates using the assumptions presented in Appendix II. The inlet landfill gas velocity measurements were calculated from the CEMS monitoring system within the landfill flare control building. In addition, airflow measurement was performed on the inlet header gas main using a pitot tube and differential manometer connected to a Testo 454/350 MxL. Temperature traverse measurements were performed across the stack in one plane only. Only one plane was possible due to access port issues. A magnesium oxide K type and PT100 thermocouple was used for measuring temperature in one landfill flares and 1-gas utilisation engine.

2.2 In stack analysis of flue gases

Flue gas analysis was performed using a pre-calibrated Testo 350 MXL/454 flue gas analyser. Concentrations of oxygen, sulphur dioxide, carbon dioxide, temperature, carbon monoxide and oxides of nitrogen were measured using electrochemical cells within the analyser box and all data was logged electronically in 1 minute intervals during the sampling exercise. Data was downloaded from the control handheld using the Com soft software and average concentrations calculated are presented within. All results presented are at 273.15 K, 101.3 kPa on a dry gas basis.

2.3 TA Luft Organics

In order to obtain samples for speciated VOC assessment, a static sampling method was used where air samples were collected in pre-conditioned Tedlar sampling bags using a vacuum sampling device. The sampler operates on the "lung principle" whereby the air is removed from a rigid container around the bag by a battery powered SKC vacuum pump filling the bag inside.

All sample bags were pre-flushed with sample air in order to prevent any reductions in the actual VOC due to sample bag surface binding. A leak check was preformed on the sample setup by placing a Primary flow calibrator inline. Once sample acquisition was completed, the sample bag was transferred to another location and connected to the sample pump, tube and Primary flow calibrator. A charcoal/anasorb sorbent was chosen to efficiently bind and pre-concentrate speciated VOC for analysis by GCMS in accordance with established and accredited methodologies. Sealed SKC sorbent tubes (SKC 226-09) were used throughout the study to maintain repeatability and integrity. In addition, the sorbent tube has a second plug to detect any breakthrough. All sampling for speciated VOC's was preformed in accordance with methodologies discussed within EN 13649:2002.

2.4 Heated Flame Ionisation Detector-Total hydrocarbon concentration (THC) determination

A heated portable FID (Signal) (Test method EN12619:1999 and EN13526:2002), heated line, controller and data logger was used to analyse the duct air stream for total hydrocarbon concentration. Once stabilised and calibrated using span gas (Propane-800 ppm; European standard), a sintered probe connected to a 181 ^{0}C heated line was place in the air stream. After stabilisation, the data logger was activated and commences reading. The FID remained analysing continuously for approximately 35 minutes in the duct air stream. Results were presented as mg [THC] m^{-3} as propane.

An FID operates on the principle where influent contaminated gas is mixed with hydrogen and the mixture is burned at the tip of a jet with air or oxygen. Ions and free electrons are formed in the flame and enter a gap between two electrodes, the flame jet and a collector, mounted 0.5-1.0 centimetres above the flame tip. A potential (400 volts) is applied across the two electrodes and with the help of produced ions, a very small current flows between the two electrodes. When an organic substance is introduced this is burned in the flame; a complex process takes place in which positively charged carbon species and electrons are formed. The current is greatly increased and therefore the sample is detected. The FID is a mass flow detector, its response depending directly on the flow rate of the carrier gas. Its response also varies with applied voltage and the temperature of the flame.

The following procedure was used for operating the FID:

1. *The FID was switched on and the oven temperature and sample line temperature were allowed to stabilise. The set-point temperatures were 180 ^{0}C sample line temperature and 200^{0}C oven temperature. This took approximately 45 minutes.*
2. *The Hydrogen/He fuel and Propane calibration gases (50 and 500 ppm) were attached to the instrument.*
3. *Once temperatures had stabilised, the instrument was started and the ignition procedure was commenced.*
4. *Once ignited, the sample procedure was commenced and any VOC upon the sample line was baked off.*
5. *The analyser was zero calibrated and span calibrated. Zero air is supplied via the clean air filter. There is less than 1% of range or 1.60 mg/m^3 in eight hours whichever is greater (see Section 6.1 of EN12619:1999 and Section 6.2.1 EN13526:2001.*
6. *The analyser calibration procedure was rechecked and recorded,*
7. *The sample line was checked by presenting calibration gas in the sample line. The value was confirmed to be the value and recorded. This reading must be less than 5% difference from the span/zero reading.*
8. *The probe was inserted into the stack.*
9. *The data logger was commenced (10 second intervals) and manual readings were taking and recorded (every 10 minutes).*
10. *The instrument was re-spanned every approximately 60 minutes to confirm calibration reading and to isolate any drift.*
11. *The recorded concentrations were converted for ppm TOC propane to mg/m^3 TOC using the equation contained in Annex E and F of EN12619:1999 and EN13526:2002, respectively.*

The analyser is MCERT and TUV approved. The MCERTS certification covers EN12619:1999 and EN13526:2002.

In order to measure total non-methane VOC's, a total non-methane hydrocarbon cutter was placed in line with the FID whereby concentrations of total volatile organic carbon and total non-methane organic were displayed digitally upon the display. This allowed for the calculation of total non-methane VOC's. All results are presented in mg/Nm^3 as propane which is in accordance with the EN13526:2002 and EN12619:1999.

2.5 Hydrogen chloride (HCL) and Hydrogen fluoride (HF) analysis

Volatile chloride and fluoride gas concentrations were determined using an impinger train containing 0.10 molar sodium hydroxide and deionised water solution, in which such gases are readily soluble. The sampling methodology was based upon USEPA Method 26 and the European Standard, EN 1911. Small sorption liquid volumes were used to attain lower limits of detection. Impingers were placed in series to ensure effective trapping of chloride and fluoride gas concentrations.

The sampling probe was placed within the stack and sample air was drawn through a heated sample line and two glass midget impingers containing 0.10 molar Sodium hydroxide positioned in series. Sampled solutions were sealed and transported to the UKAS accredited *laboratory for analysis via ion chromatography (RPS Analytical laboratory, Manchester, UK). The results of mg m^{-3} have been converted to mg Nm^{-3} at 273.15 K, 101.3 kPa.*

3. Results-Emission testing.

This section will present the results of the monitoring exercise.

3.1 Sampling time

Table 3.1 summarises the sampling times for stack monitoring. Table 3.2 illustrates the inlet landfill gas parameters as characterised from the CEMS analyser system operating within the landfill flare control building. In addition, manual monitoring was performed using a GA2000 landfill gas analyser. The total volume of landfill gas utilised by the landfill flare during monitoring was 449 m^3/hr.

All outlet gas samples were taken approximately 1.20 metres below the top of the stack for the landfill flare. All sampling was performed through the existing 25mm and 100 mm sampling ports on the landfill flare. A one-plane oxygen and temperature traverse was performed to assess any difference in oxygen concentrations and temperature across the sampling plane. Temperature and Oxygen differences were less than the 15% deviation level as recommended by the UK Environmental Agency (Guidance for monitoring enclosed Landfill flares, 2002).

3.2 Volumetric flow rate results

Table 3.3 summarises the theoretical airflow rate calculations for the Landfill gas flare. Table 3.3 includes the stack velocity, expressed in metres per second (m/s) and exhaust volumetric airflow rate expressed in m^3/hr at both actual and standard reference conditions of 273.15 K, 101.3 kPa (i.e. standard temperature and pressure).

3.3 Flue gas concentration results

Flue gas concentrations were monitored using a pre-calibrated Testo 350/454 MXL flue gas analyser. The results of SO_2, NO_x as NO_2 + NO, CO, and O_2 are presented in Table 3.4. The results of ppm have been converted to mg Nm^{-3} at 273.15 K, 101.3 kPa, on a dry gas basis with correction for oxygen content. In accordance with EPA flare monitoring requirements, Oxygen correction to 3% should be performed for landfill gas flare. The average temperature of the gas analyser on the day of sampling was 282.15 K.

3.4 TA Luft Organics

TA Luft Organics concentrations were monitored using sorbent tubes and analysis by GCMS. The results of TA Luft organics are presented in Table 3.4. The results are presented as mg Nm^{-3} at 273.15 K, 101.3 kPa, with correction for oxygen content. In accordance with EPA flare/gas utilisation engine monitoring requirements, Oxygen correction to 3% should be performed for landfill gas flares. The average temperature of the sampling tubes on the day of sampling was 283.15 K.

For the concentration of TOC adsorbed on to the charcoal tube, the mass amount of absorbed volatile organic carbon was measured using gas chromatography flame ionisation detector (GC-FID). Once the sampled volume is known, the mass concentration of VOC within the sampled gas could be calculated.

3.5 Total hydrocarbon concentration (THC) results

THC concentrations were monitored using a pre-calibrated FID analyser. The results of THC are presented in Table 3.4. The results of ppm have been converted to mgC/Nm^3 at 273.15 K, 101.3 kPa, with correction for oxygen content. Conversion from ppm to mgC/Nm^3 was performed using a 1.60 multiplication factor for propane. In accordance with EPA monitoring requirements, Oxygen correction to 3% should be performed for landfill flares. The average temperature of the FID on the day of sampling was 454 K.

3.6 Total non-methane volatile organic compound (TNMVOC) results

Table 3.4 illustrates the results of the continuous non-methane volatile organic compounds (TNMVOC) on the monitoring location. The monitoring of TNMVOC was performed using a TNMVOC hydrocarbon cutter and a continuous monitoring Flame ionisation detector operated in accordance with EN13526:2002. The monitoring of THC will provide the total hydrocarbon concentration including any propane or methane fraction within the airstream. The use of a hydrocarbon cutter facilitates the removal of the methane and propane fraction from the airstream and the presented results therefore consist of the non-methane fraction only.

3.7 Hydrogen chloride (HCL) and Hydrogen fluoride (HF)

Hydrogen chloride and hydrogen fluoride concentrations were monitored using an impinger train containing 0.10 molar sodium hydroxide and deionised water solution, in which such gases are readily soluble. The results of hydrogen chloride and hydrogen fluoride are presented in Table 3.4. The results of mg/m^3 have been converted to mg/Nm^3 at 273.15 K, 101.3 kPa, with correction for oxygen content. In accordance with EPA flare, Oxygen correction to 3% should be performed for a landfill gas flare.

Table 3.1. *Sampling time runs on the 15th Jan. 2010 for monitoring of landfill flare.*

Parameter	Approx. Sampling period for 1 landfill flare
Inlet CH_4	45 minutes
Inlet O_2	45 minutes
Volumetric air flow rate	Theoretically calculated
SO_2	45 minutes
NO_x	45 minutes
CO	45 minutes
O_2	45 minutes
CO_2	45 minutes
Stack gas temp	45 minutes
TNMVOC	45 minutes
TA Luft Organics	45 minutes

Table 3.2. *Characteristics of raw inlet gas to one enclosed Landfill flare gas burner.*

Inlet compound identity	Compound loading Landfill flare	Unit values
CH_4	24.40	%
CO_2	28.43	%
O_2	7.35	%
Total Landfill gas volumetric airflow rate	449	m^3/hr

Table 3.3. *Theoretically calculated landfill gas exhaust volume and physical characteristics from the Landfill flare.*

Parameter	*Enclosed flare*
Total Volumetric methane loading (m^3/hr)	*109.50*
Total Volumetric Oxygen loading (m^3/hr)	*33*
Ratio to complete combustion of methane assuming no excess Oxygen	*9.57*
Oxygen concentration level in flue gas (%)	*14.58*
Flue gas temperature (Kelvin)[2]	*1,208*
Theoretical calculated Volumetric exhaust airflow rate (m^3/h)	*4,842*
Normalised average exhaust airflow rate ($Nm^3\ h^{-1}$)[3]	*1,094*

Notes: [1] *denotes data from 15th Jan. 2010.*
[2] *denoted converted from degrees Celsius to Kelvin (^{0}C + 273.15);*
[3] *denotes normalised to 273.15 Kelvin and 101.3 kPa.*

Table 3.4. *Emission value results for one landfill gas flare.*

Parameter	Values	Units	Adjusted units (mg/m^3)	Normalised Volumetric flow rate (Nm^3/hr)	Oxygen corrected emission conc to 3 % (mg/Nm^3)[2]	Mass emission rate (kg/hr)	Emission limits
Carbon monoxide (CO)	7	ppm	8.75	1,094	24.78	0.0096	<50 mg/m^3
Temperature	935	degrees	1208K	1,094	-	-	-
Oxygen (O_2)	14.58	%	14.58	1,094	-	-	-
Total NOx [as NO_2]	14	ppm	28.75	1,094	81.43	0.0315	<150 mg/m^3
Sulphur dioxide (SO_2)	21	ppm	60	1,094	169.94	0.0657	-
Carbon dioxide (CO_2)	4.17	%	4.17	1,094	-	-	-
TOC	3.12	ppm	4.99	1,094	14.14	0.055	-
Ta Luft Organics – Class I, II and III	2.43	mg/m^3	2.43	1,094	7.39	0.0029	<20 mg/m^3 (at mass flows > 0.1 kg/hr)
Hydrogen chloride	7.13	mg/m^3	7.13	1,094	27.59	0.0107	<50 mg/m^3 (at mass flows > 0.3 kg/hr)
Hydrogen fluoride	1.18	mg/m^3	1.18	1,094	4.57	0.0018	<5 mg/m^3 (at mass flows > 0.05 kg/hr)
Volumetric air flow rate	1,094	Nm^3/hr	-	-	386	-	<3,000
Inlet methane conc	1.74 E5	mg/Nm^3	1.74 E5	-	-	190.36	-
Combustion Eff.	99	%	-	-	-	-	-

Notes: [1] *denotes refer to Appendix II for Oxygen correction calculations.*
[2] *denotes units normalised to 3% O_2 for flare.*
[3] *denotes limit values for TA Luft Organics Class I 20 mg/m^3, Class II 100 mg/m^3, Class 150 mg/m^3 total concentrations recorded are less then Class*

4. Discussion of results

Tables 3.1 to 3.4 present the results of the emission monitoring carried out on the landfill flare stack burner and one utilisation engine located in Silliot Hill Waste Management facility.

There was very little variation at one traverse in oxygen and flue gas temperature profiles across the stack during the monitoring exercise (i.e. less than 15% as recommended by the Environment Agency, UK (Environment Agency, 2002)).

A high temperature Inconel 625 and ceramic probe (Testo, Germany) was used to prevent variations in CO emissions data. Normal stainless steel probes when subjected to temperatures above 600^0C can release CO from within the structure of the material and cause the recording of erroneous results (Environment Agency, 2002).

Correction of data to 3% oxygen was performed. Due to possible inaccuracies in airflow rate measurement, it was not possible to determine the oxygen intake of the flare through the louver system using measurement. Since the volume of intake air required for complete combustion was known and the oxygen concentration in the exhaust flue gas was known, the volume of intake excess fuel air could be theoretically calculated through numerous iterations using the Solver program (i.e. Microsoft Excel). This allows for the calculation of the volume of intake excess air through the louver landfill flare intake system. These calculations were validated through use of the published Environment Agency equation (see Eqn 8.3.1) (Environment Agency, 2002).

Landfill methane destruction efficiency was calculated using the inlet methane loading concentration and the exhaust total methane hydrocarbon concentration as presented in Table 3.4. As can be observed, the landfill flare is achieving a methane destruction efficiency of greater than 99%. Typical reported concentrations of methane from landfill flare burner systems are in the order of 0.040% to 0.52%. The complete combustion of methane results in the formation of CO_2 and H_2O. The incomplete combustion of methane results in the formation of CO. CO concentration levels was low in the flue gas of the landfill flare.

5. Conclusion

The following conclusions can be drawn from this study:

1. *A theoretically exhaust flue gas volume was calculated for the landfill flare.*
2. *NO_x as NO_2, SO_2, CO, O_2, TA Luft Organics, TOC, HCL and HF monitoring and analysis was carried out in accordance with specified requirements;*
3. *All data was standardised to 273.15 Kelvin, 101.3 kPa;*
4. *All data is presented as Oxygen corrected to 3% (v/v) using the appropriate equations as presented in Section 8.2;*
5. *CO, NO_x as NO_2, HCL, HF and TA Luft Organics in the landfill flare exhaust stack were within the emission limit values specified in Schedule C.4 or Waste licence W0014-01.*

6. References

1. *Environment Agency. (2002). Guidance for Monitoring Enclosed Landfill Gas Flares. www.environment-agency.co.uk*
2. *McVay, M., (2003). Personal communication. Environment Agency, Wales, UK.*
3. *ISO 10780, (1984). Stationary source emissions-Measurement of velocity and volume flow rate of gas streams in ducts.*

- *IS EN13526:2002-Stationary source emissions-Determination of the mass concentration of total gaseous organic carbon in flue gases from solvent using processes-Continuous flame ionisation detector method.*

- *IS EN12619:1999-Stationary source emissions-Determination of the mass concentration of total gaseous organic carbon at low concentrations in flue gases-Continuous flame ionisation detector method.*
- *I.S. EN13649:2002-Stationary source emissions-Determination of the mass concentration of individual gaseous organic compounds-Activated carbon and solvent desorption method.*

7. Appendix I - Sampling, analysis and calculation details

7.1.1 Location of Sampling

Silliot Hill waste management facility, Silliot hill, Brownstown, Co. Kildare.

7.1.2 Date & Time of Sampling

15th January 2010

7.1.3 Personnel Present During Sampling

Dr. John Casey, Odour Monitoring Ireland, Trim, Co. Meath.

7.1.4 Instrumentation

Testo 350 MXL/454 in stack analyser;
Federal Method 2 S type pitot and MGO coated thermocouple;
L type pitot tube
Testo 400 handheld and appropriate probes.
Ceramic and Inconel 625 sampling probes.
Portable Signal 3030PM FID calibrated with Propane with non-methane hydrocarbon cutter.
SKC sample pumps and Bios Primary calibrator

8. Appendix II - Example calculations and conversions

8.1 Conversion of 14 ppm Oxides of nitrogen to mg Nm^{-3} at 273.15 Kelvin and 101.3 kPa (STP) for Landfill flare 1

1 mole of an ideal gas occupies 22.4 litres at standard temperature and pressure of 273.15 Kelvin[1] and 101.3 kPa (STP), where a mole of any substance is equal to its molecular mass and expressed in grams.

This is known as molar mass (i.e. the volume occupied by one gram mole of a gas at STP).

Using the average recorded concentration (in ppm) for NO_2 during the survey, the conversion is as follows:

1 mole of NO_2 occupies 22.4 litres @ STP

46 grams (Molecular weight of NO_2) occupies 22.4 litres @ STP

mg/m^3 NO_2 = 14 ppm × 46 / 22.4 = 28.75 mg/Nm^3

Notes:
[1]denotes conversion of ^0C to Kelvin: $^0C + 273$ = Kelvin, normalisation temperature is the recorded temperature of the stack analyser

8.2 Additional calculations and correction of Oxygen concentration measured to reference Oxygen concentration of 3% (v/v) for 28.75 mg/Nm^3 of NO_X as NO_2 for Landfill flare.

If excess air is added to an enclosed landfill flare (i.e. to promote better combustion), measured flue gas emission concentration of non-combustion species will fall. Emission concentrations appear to be reducing, whilst in reality mass emission rates have remained constant (Environment Agency, 2002). Therefore, it is necessary to compare concentrations at a standard oxygen concentration.

The relationship between the measured oxygen concentration and measured emission species concentration is non-linear as oxygen from air is added or removed. For example, a halving of the flue gas oxygen content does not result in a doubling of the emission concentration. The oxygen concentration in the flue gases is a measure of the excess air over that required for theoretical complete combustion (i.e. stiochiometric air requirement). Therefore, the measured oxygen level is a measure of the dilution of the flue gases from the stoichiometric condition. The concentration of oxygen in dry air is 20.9% (v/v) and the proportion of excess air (X/V) can therefore be calculated from the following:

$$\frac{X}{V} = \frac{(O_2)_m}{(20.9 - (O_2)_m)} \quad \textit{(\textbf{Eqn 8.3.1})}$$

Where: X is the volume of excess air (m^3);
V is the stoichiometric volume of the flue gas (m^3);
$(O_2)_m$ is the percentage of oxygen (v/v) in the flue gas (on a dry basis).

If we know and calculate the following:

The volume of landfill gas was 449 m^3/hr with a methane and oxygen concentration of 24.4% (v/v) and 7.35%(v/v) as taken from the landfill gas analyser.

This equates to a methane and oxygen volume of 109.55 m^3/hr and 33m^3/hr, respectively.

*The stiochiometric ratio of oxygen to methane for combustion is **2:1** as shown below:*

$$\mathbf{1}CH_4 + \mathbf{2}O_2 + 7.52\ N_2 \longrightarrow CO_2 + 2H_2O + 7.52\ N_2 + \text{Heat} + \text{Light}$$

*Ambient air contains 20.9% (v/v) oxygen, therefore stiochiometric volume ratio of air required for complete combustion of methane is **9.57 times** methane volume.*

Since the volume of oxygen in inlet landfill gas and stiochiometric ratio required is known, the total amount of intake air required for complete combustion is:

$$(109.55\ m^3\ h^{-1} \times 9.57) - 33\ m^3/hr = \mathbf{1{,}015.39\ m^3/hr}. \quad (\textbf{Eqn 8.3.2})$$

Therefore the total volume of flue gases exhausted through stack assuming total combustion and 0% (v/v) oxygen in flue gas is:

Volume of landfill gas + Volume of Inlet air = Total Volume of flue gas

449 m^3/hr + 1,015.39 m^3/hr = 1,464 ***m^3/hr (Eqn 8.3.3)***

In reality excess inlet air is taken into the landfill flare gas burner to ensure this combustion.

The measured oxygen concentration within the flue gas of the landfill flare in Silliot Hill Waste Management Facility was 14.58 % (v/v) dry gas basis.

Therefore excess amounts of inlet air are being taken in through the louver system. As the airflow rate measurement may be highly inaccurate a back calculation method is used to calculate the amount of excess air taken into the flare burner using known combustion volume and flue gas Oxygen concentration % (v/v). This is shown below:

The following units are known:

- *Volume of flue gas assuming total combustion and 0% (v/v) oxygen in flue gas outlet $V_{Flue\ gas}$ = 1,464 m^3/hr;*
- *Volume of measured excess Oxygen % (v/v) in flue gas outlet $(O_2)_{outlet}$ = 14.58% (v/v);*
- *Volume of excess inlet air to increase flue gas to measured Oxygen % (v/v) concentration V_{inlet} = unknown*
- *Oxygen concentration in inlet air $(O_2)_{inlet}$ = 20.9% (v/v)*

Using a back calculation formula, and numerous iterations using Solver formula equation in Microsoft Excel, the volume of excess air added to the landfill flare burner system is V_{inlet} = 3,378 m^3/hr which equates to a total excess Oxygen volume $(O_2)_{volume}$ = 706 m^3/hr. Based on this, the calculated total volume of flue gas from the landfill flare would be ***4,842.8 m^3/hr.***

The following simple equation illustrates validation of the assumptions used and calculated:

$$\%O_{2Outlet} = \left(\frac{O_{2volume}}{V_{Fluegas} + V_{inlet}}\right) \times 100 \quad \textbf{\textit{(Eqn 8.3.4)}}$$

Referring back to Equation 8.3.1, the percentage proportion of excess air can then be calculated as below:

$$\left(\frac{3,378}{1,464} = \frac{14.58}{20.9 - 14.58}\right) \quad \textbf{\textit{(Eqn 8.3.5)}}$$

Therefore the percentage proportion of excess air over required fuel air is near 230%. Equation 8.3.5 could also be used to calculate the volume of excess air.

Since the volume of excess air into the landfill flare burner is known, then the ratio of overall intake air over intake landfill gas can be calculated:

$$\text{Ratio}_{air} = \frac{3,378\text{m}^3\text{hr}^{-1}}{449\text{m3/ hr}} \quad \textbf{\textit{(Eqn 8.3.6)}}$$

Therefore Ratio $_{air}$ = 7.52 which can be expressed as ***1:7.52****. This is a common occurrence in landfill flare burners although a value closer to 9 is more frequent.*

For oxygen correction, the following calculation can be performed:

$$C_r = C_m \times \frac{(20.9 - (O_2)_r)}{(20.9 - (O_2)_m)} \quad \textit{(\textbf{Eqn 8.3.7})}$$

Where: C_r *= referenced concentration;*
C_m*= measured concentration;*
$(O_2)_r$ *= reference oxygen concentration (3% (v/v) for Landfill flare burners);*
$(O_2)_m$ *= measured oxygen concentration in flue gas (14.58% (v/v)).*

Hence the equation can be written as follows:

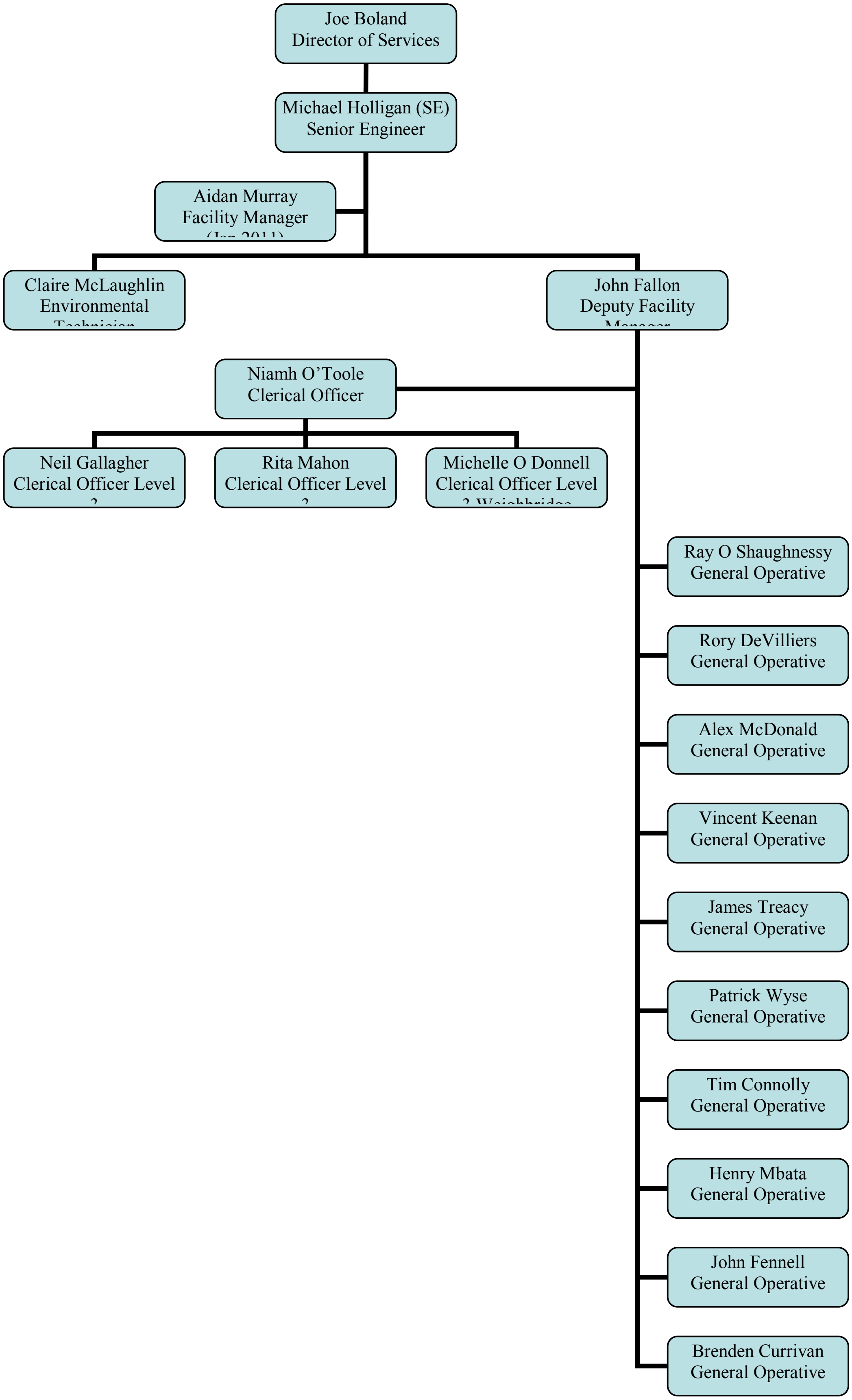
$$C_r = C_m \times \frac{17.9\%}{6.32\%} = C_r = C_m \times 2.83 \quad \textit{(\textbf{Eqn 8.3.8})}$$

For a NO_2 *concentration of 28.75 mg/Nm*^{3} *then the oxygen corrected value (3% (v/v)) would be as follows:*

$C_r = 28.75 \times 2.8322$ ***= 81.43 mg/Nm***^{3} ***referenced to 3% oxygen (v/v) dry gas.***

Appendix IV

Staff Structure



Joe Boland
Director of Services
Michael Holligan (SE)
Senior Engineer
Aidan Murray
Facility Manager
Claire McLaughlin
Environmental
John Fallon
Deputy Facility
Niamh O'Toole
Clerical Officer
Neil Gallagher
Clerical Officer Level
Rita Mahon
Clerical Officer Level
Michelle O Donnell
Clerical Officer Level
Ray O Shaughnessy
General Operative
Rory DeVilliers
General Operative
Alex McDonald
General Operative
Vincent Keenan
General Operative
James Treacy
General Operative
Patrick Wyse
General Operative
Tim Connolly
General Operative
Henry Mbata
General Operative
John Fennell
General Operative
Brenden Currivan
General Operative

Appendix V

Slope Stability Report

June 2010

SILLIOT HILL INTEGRATED WASTE MANAGEMENT FACILITY

Closed Landfill Slope Stability Assessment

Submitted to:
Claire McLaughlin
Kildare County Council
Silliot Hill Integrated Waste Management Facility
Kilcullen
Co. Kildare

REPORT

Report Number. 09507190398.501/A.0

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Table of Contents

1.0 INTRODUCTION

Kildare County Council (KCC) owns and operates an Integrated Waste Management Facility (IWMF) known as Silliot Hill in Kilcullen, Co. Kildare. This facility is a former residual waste landfill site which ceased waste acceptance in 2002 and has subsequently been capped and restored with most of the site now covered with grass with the landfill gas and leachate infrastructure visible at the surface.

The Council has developed the site to provide an IWMF which is accessible to the public and commercial operators as well as the Council. As part of this installation, a large portal framed industrial building has been constructed which functions as a waste transfer station. This building is located at or around the base level of the landfill and the waste is sloped away from the building and its access roads; in some areas, the base of this infrastructure is partly constructed on waste.

The IWMF operates within the requirements of a Waste Licence No. W0014-01.

2.0 BACKGROUND

As stated above, a Waste Licence exists for the IWMF at Silliot Hill and this covers a range of requirements. Of particular relevance to this report is Condition 8.10.2 which states:

"Within six months of the date of grant of this licence, and annually thereafter, the licensee shall carry out a stability assessment of the side slopes around the transfer station".

In order to comply with the requirements of this condition, the Council employed Fehily Timoney and Company in February 2009 to undertake a detailed numerical evaluation and assessment (Ref. 1). This assessment considered a number of slopes around the facility the failure of these slopes by different methods. This resulted in a series of Factors of Safety being presented.

In April 2010, KCC approached Golder Associates (Ireland) Ltd (Golder) to undertake an inspection of the facility slopes in order to satisfy the requirements of the licence. Golder did not propose to revisit the work undertaken by Fehily Timoney and Company, but to carry out a visual inspection of the site giving particular attention to the slopes.

3.0 SITE INSPECTION METHODOLOGY

Golder proposed to the Council that a full Stability Risk Assessment involving significant numerical evaluation and modelling was not required as the stability of the slopes had already been demonstrated by Fehily Timoney and Company. Instead, Golder proposed a visual inspection of the slopes and environs looking for the following:

- *Signs of distress – e.g. cracking, particularly at the top of the slopes;*
- *Signs of movement – e.g. bulging in the slope and/or depressions at the top of the slopes;*
- *Disturbance of or discontinuities in vegetation;*
- *Evidence of significant ingress/egress of water; and*
- *Evidence of movement or distress to surrounding structures, including roads, retaining walls and slabs.*

4.0 SITE INSPECTION

Please refer to the Photographic Plates accompanying this report.

4.1 General

Golder visited the site on the afternoon of Monday 24 May 2010 and walked over all of the slopes and upper areas of the site as well as the access to the transfer station and the surrounding roads and yards. The weather was dry and sunny, with very good visibility. No intrusive investigations were undertaken.

The dry sunny weather during the inspection had also been the prevailing conditions over the previous weeks and so there was no presence of water anywhere on the site. This meant that the adequacy and function of the installed capping and restoration drainage infrastructure which had been installed could not be assessed. However, the location and size, as well as the detailing that was visible, were all deemed to be appropriate.

Landfill gas extraction is currently active and feeds a 1500 m^3/hr flare. There is a gas engine at the site but this is not operational. It is understood that KCC is currently planning to carry out a LFG pumping trial at the site, in order to size for a new flare. It should be noted that increasing the rate of gas abstraction will lead to a change in the waste mass and this may affect the slope.

No leachate levels were provided to Golder and it is assumed that the leachate levels are controlled within limits considered in the analysis carried out by Fehily Timoney and Company.

4.2 Restored Landfill

Most of restored areas inspected, including slopes, were heavily vegetated with grass and weeds, with the exception of the to the south of the transfer station access road where, according to Council staff present at the site, the topsoil had been washed off during heavy rain prior to seed taking root. This area was sparsely covered with weeds.

The thorough visual inspection of the slopes and the land above did not indicate any signs of movement, distress or slips indicated by bulges or depressions. There were no signs of cracking due to drying shrinkage of the topsoil or, on the slope with no topsoil, the sub-soil. This indicates that, despite the prolonged dry weather, a certain amount of moisture has been retained in the materials, also evidenced by the healthy condition of the vegetation, which means that the cohesive properties of these materials are being maintained.

As mentioned above, the prolonged dry weather meant that an assessment on the performance of the drainage measures could not be ascertained and it is possible that saturation of the soil materials could occur if the drainage does not perform effectively. However, over the past year a number of significant rainfall events have occurred and the continued stability of the slopes is a fair indication that these measures are effective in preventing saturation of the soils.

4.3 Leachate and Gas Infrastructure

Various items of landfill gas and leachate management infrastructure are present on the site and these were observed from the surface without gaining entry into any chambers. None of these appeared to show signs of distress, with one notable exception which is a large manhole chamber to the north of the access road, approximately 15 m from the transfer station yard. This shows a HDPE pipe which turns through approximately 90° from under the landfill to the north of the access road, to vertical down. The bend has been squashed and pushed, suggesting that the near horizontal pipe beneath the landfill has settled forcing the bend to squash and push out the vertical section. This scenario is to be expected as the waste in the site degrades and settles and is not a sign of failure of the slopes. It is, however, recommended that this installation is reviewed by the Council to verify the function of the pipe and to take action to prevent failure if such failure poses a risk to health, safety or the environment.

4.4 Roads and Slabs

The access road leading from the wheelwash to the transfer station, as well as the concrete slabs to the southeast and northwest of the transfer station were also inspected.

The roads did not exhibit any significant deterioration that would be associated with slope failure, such as heave with associated tension cracking. The slab to the southeast of the transfer station is exhibiting signs of failure due to differential settlement, but this is not due to failure of the slopes but is likely to be due to poor sub-grade beneath the slab, possibly coupled with poor construction details.

4.5 Retaining Walls

The access road has retaining walls on both sides, approximately 1m in height. These are made up of sectional inverted 'V' units and have a 'key clamp' type handrail fitted to their upper surface. An in-situ retaining wall, approximately 2 m in height, meets these walls approximately 2 m from the end of the access road, and is continuous around the yard and through the building.

The small retaining walls adjacent to the road are all intact, although these units are most likely to be reliant on gravity only and so failure of these would be exhibited by sliding.

The larger retaining wall around the transfer station has a major crack approximately 6 m from the south eastern end. This crack is immediately adjacent to a construction joint and is approximately 50 mm at the base and 10 mm at the top and is coincident with a crack across the concrete yard slab. This crack has most likely been induced by settlement of the wall foundation and slab to the south west causing a rotation and failure at this point. Golder suggested that this has been present for a considerable time and this is reinforced by the presence of remnants of 'tell tale' crack width gauges; Council staff at the site confirmed that this is the case. Whilst this does not present an immediate risk, the crack has exposed reinforcement within the wall and deterioration of the reinforcement by corrosion, will lead to a reduction in capacity of the wall and potentially a localised failure which is likely to be minor.

5.0 SUMMARY AND CONCLUSIONS

The survey undertaken by Golder on Monday 24 May 2010, indicates that the slopes surrounding the transfer station at Silliot Hill IWMF are not showing signs of deterioration and this coupled with the detailed assessment undertaken by Fehily Timoney and Company means that the slopes are currently stable.

6.0 RECOMMENDATIONS FOR FUTURE INSPECTIONS

Based on the information made available to Golder and the site inspection undertaken on Monday 24 May 2010, Golder makes the following recommendations:

1) *Site drainage infrastructure should be observed during a period of heavy rainfall to confirm that it is functioning correctly and that excess water is not being discharged to the soils;*

2) *If active gas extraction is increased, a walkover survey similar to that as described above should be undertaken;*

3) *Monitoring of the retaining wall crack should be undertaken on a quarterly basis. This should comprise simple measurement of the crack width at, say, 0.5 m, 1 m, 1.5 m and 2 m so that changes are highlighted. Use of a plumb line to monitor the verticality of the wall either side of the crack is also recommended. In addition, photographs of the exposed reinforcement should be taken and compared with previous photographs to monitor deterioration;*

4) *During general operation of the facility, operations staff should be encouraged to advise management of anything which they observe to have changed – e.g. signs of slopes bulging, retaining walls moving, cracks forming in slopes etc. Management can then further investigate, compare to records and seek professional opinion where there is cause for concern; and*

5) *Annual inspections are to be undertaken by site management who are familiar with the site. The procedure outlined above should be followed with extensive photographic records retained, with*

photographs, where possible, taken in the same location each year so that changes can be noted. Where changes are observed an Engineer should be consulted to provide advice.

7.0 REFERENCES

1 *Fehily Timoney & Company, Slope Stability Report, Silliot Hill Integrated Waste Management Facility, Kilcullen, County Kildare, February 2009, Ref: 2006\114\01\Reports\KCC-EM_Rpt022-0.*

Report Signature Page

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Date: 08 June 2010

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VAT No.: 8297875W

APPENDIX A

Plates

Plate Nr: *1* **Caption:** *Waste Transfer station building*	
Plate Nr: *2* **Caption:** *Slope to east of building*	
Plate Nr: *3* **Caption:** *View along east of building (looking south)*	

Plate Nr: *4*	
Caption: *Further along east of building (looking south). Note regular shape of slope.*	
Plate Nr: *5*	
Caption: *Bench level (approx. 3 m in width) on eastern slope.*	
Plate Nr*: 6*	
Caption: *View (looking west) from top of eastern slope with landfill gas (LFG) infrastructure to left.*	

***Plate Nr**: 7* ***Caption:** View looking southwest from top of eastern slope.*	
***Plate Nr:** 8* ***Caption:** View looking northwest from slope above access road to the east of the building.*	
***Plate Nr:** 9* ***Caption:** Slope to south east of building, looking west past south of building.*	

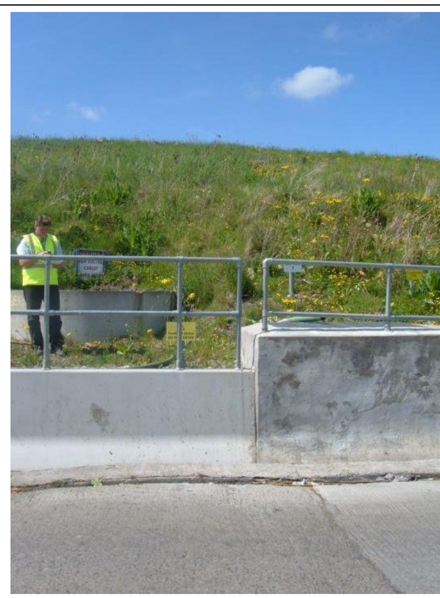
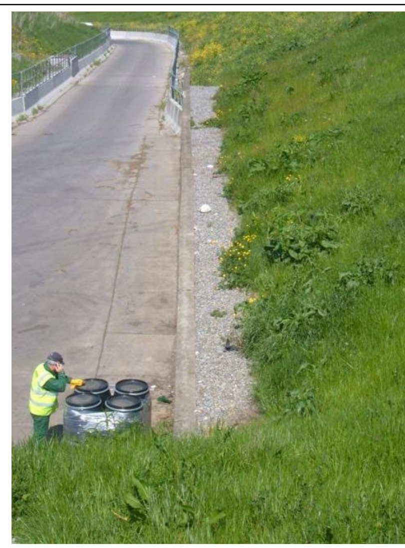
Plate Nr: *10*	
Caption: *Looking east along slope bench ; slope to north of WTS access road.*	
Plate Nr: *11*	
Caption: *View along retaining wall to edge of access road with chambers visible in foreground.*	
Plate Nr: *12*	
Caption: *Looking north across access road to pipe chamber and slope.*	

Plate Nr: 13 **Caption:** Looking northwest from access road to building. Note higher retaining wall which extends into building.	
Plate Nr: 14 **Caption:** View of retaining wall unit to north of access road.	
Plate Nr: 15 **Caption:** Retaining wall to south of yard where it meets wall adjacent to the access road.	

<table>
<tr><td>Plate Nr: 16</td><td rowspan="2"></td></tr>
<tr><td>Caption: Looking east at slope to south of access road. Photograph taken at edge of higher retaining wall. Note regularity of slope angle.</td></tr>
<tr><td>Plate Nr: 17</td><td rowspan="2"></td></tr>
<tr><td>Caption: Again looking east as plate 16. Photograph taken further west. Note change in vegetation highlighting lack of topsoil on slope adjacent to access road.</td></tr>
<tr><td>Plate Nr: 18</td><td rowspan="2"></td></tr>
<tr><td>Caption: Close up of slope to south of access road. Note lack of topsoil.</td></tr>
</table>

Plate Nr: 19 **Caption:** Looking west along top of retaining wall to south of building yard.	
Plate Nr: 20 **Caption:** Similar view to plate 19. Note wall in background (to southwest of building) dipping to left of photograph.	
Plate Nr: 21 **Caption:** View from slope to southwest of yard, looking east along yard retaining wall and access road.	

<table>
<tr><td>Plate Nr: 22

Caption: Looking north along retaining wall from southwest corner of yard.</td><td></td></tr>
<tr><td>Plate Nr: 23

Caption: Looking north along slope to west of building. Note gravel drainage trench running north to collection chamber.</td><td></td></tr>
<tr><td>Plate Nr: 24

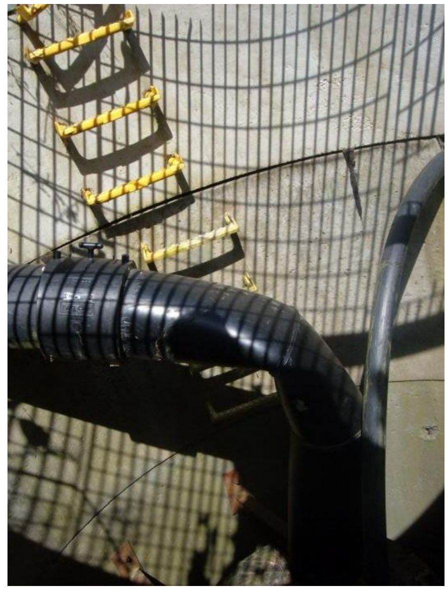
Caption: Higher up slope again looking north along slope to west of building. Note infrastructure to left of photograph.</td><td></td></tr>
</table>

Plate Nr: *25* ***Caption:*** *View of infrastructure referred to in plate 24.*	
Plate Nr: *26* ***Caption:*** *View of southern section of drainage trench referred to in plate 23.*	
Plate Nr: *27* ***Caption:*** *View of drainage outfall to collection chamber referred to in plate 23.*	

Plate Nr: *28* ***Caption:*** *Looking south along the western slope along the line of the gravel drainage trench.*	
Plate Nr: *29* ***Caption:*** *Further view along gravel drainage trench as plate 28. Note pipe surrounded in geotextile filter.*	
Plate Nr: *30* ***Caption:*** *View south along west of building. Note: retaining wall terminating in return to the front right of the building; regular profile of slope; infrastructure to side of building and on top of slope in background.*	

Plate Nr: 31 **Caption:** Flat area above slope to south of access road. Note gravel drainage trenches and infrastructure.	
Plate Nr: 32 **Caption:** Gravel drainage trench to west and southwest of pylon in plate 31. Note regular profile of slope.	
Plate Nr: 33 **Caption:** Drainage trench outfall – note pipe wrapped in filter geotextile.	

Plate Nr: *34*	
Caption: *Further site infrastructure to southwest of pylon.*	
Plate Nr: *35*	
***Caption:*.** *Looking west along slope to south of access road. Again note regular profile of slope.*	
Plate Nr: *36*	
Caption: *Squeezed pipe in chamber to north of access road. See plate 12 for location.*	

Plate Nr: *37*	
***Caption:**. Squeezed pipe in chamber to north of access road.*	
Plate Nr: *38*	
***Caption:** View of retaining wall to south of yard.*	

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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