Appendix D

Air Quality
Envirocon Ltd.

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AIR QUALITY IMPACT OF PROPOSED LANDFILL EXTENSION GORTADROMA, CO. LIMERICK

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Date: 12 December 2003 **Report By: Michael L. Bailey**

1.0 INTRODUCTION

The existing landfill facility at Gortadroma, Ballyhahill, Co. Limerick is to be extended to provide additional capacity for the disposal of municipal waste and non-hazardous commercial/industrial waste from Limerick City and County for the next 15 to 20 years. The present landfill is Licenced (No 17-2) under the Waste Management Act 1996 by the Environmental Protection Agency. The proposed extension area is to the east of the existing landfill facility. As part of the evaluation of the environmental impact of this proposed development, an assessment of the impact on air quality was undertaken by Envirocon Ltd.

The present landfill facility is licenced to take 130,000 tonnes per year of waste under the existing waste licence and additional cells are required to allow filling to continue at Gortadroma after 2005. The extension area will comprise a number of lined cells within a total planned site area of approximately 41 hectares. Each cell will provide approximately 3 - 4 years filling capacity. The completed cells will be progressively capped and restored and the landfill gas collected and directed to an energy utilisation plant. There will be a 200m buffer zone between the road and the southern extent of the filling area.

The existing access road into the landfill, reception infrastructure including the weighbridge, wheel-wash and civic amenity disposal area and the landfill gas flare/gas engine compound will remain at their present locations. Leachate from the proposed extension will be collected and piped to the present treatment system.

2.0 METHODOLOGY

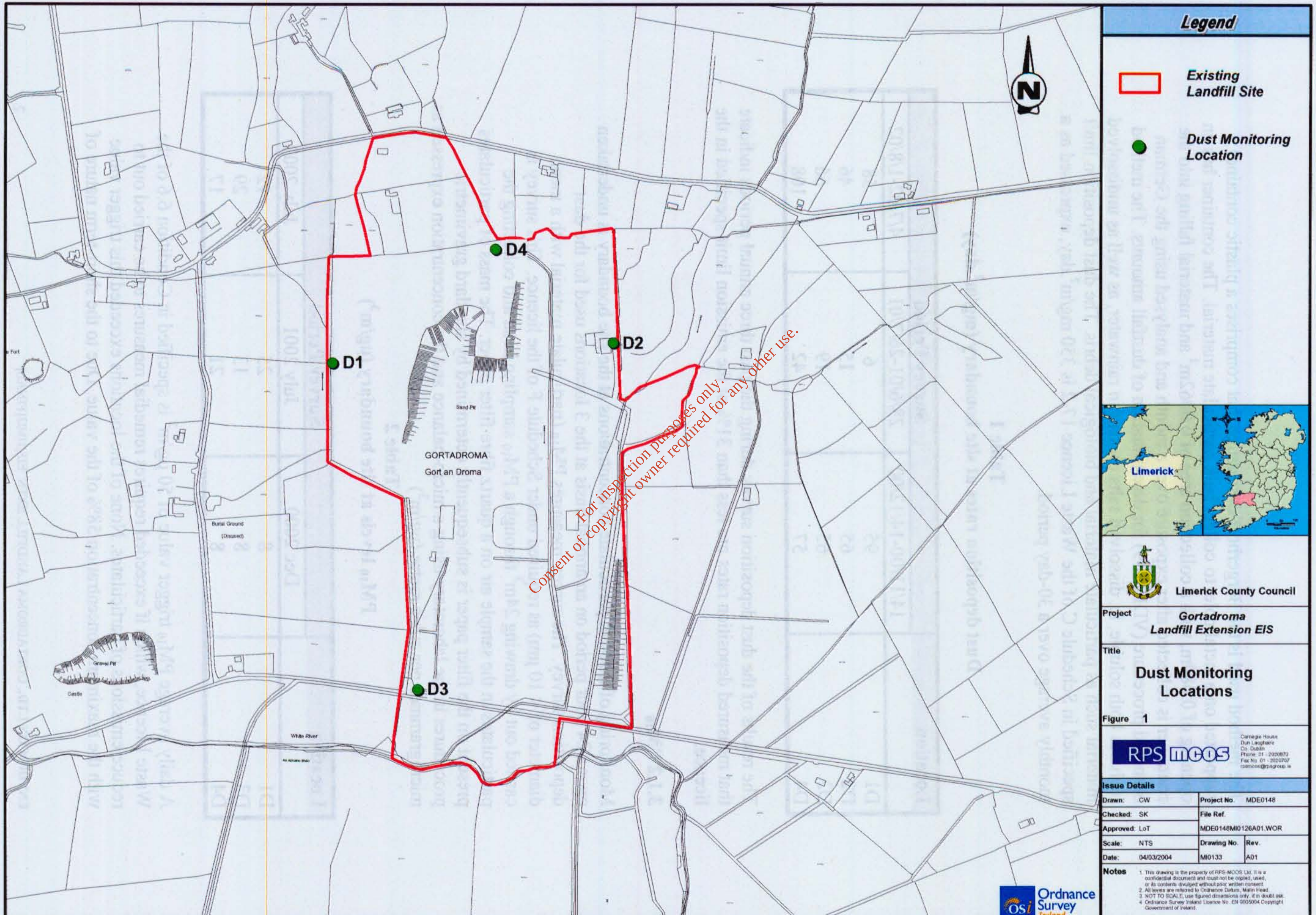
The assessment of the existing environment for this EIS has been based on monitoring studies of dust, particulates and odours undertaken as part of the Waste Licence conditions and the assessment of ambient sulphur dioxide and nitrogen dioxide concentrations carried out in 1997. An evaluation of the impact of the operation of the planned extension was based on a review of the present operating procedures in relation to cell management and infrastructural requirements and the operation of the gas collection/flare-stack system.

3.0 EXISTING ENVIRONMENT

3.1 Ambient Air Quality

3.1.1 Dust

Dust deposition monitoring is carried out at four locations near the site boundary for one month over a year as required under Schedule D of the Waste Licence, 17.2. The four locations, designated D1-D4, are shown in **Fig 1** Site D1 is located along the western boundary, Site D2 is near the eastern boundary, Site D3 is close to the site entrance and Site D4 is located along the northern boundary.



Legend
Existing Landfill Site
Dust Monitoring Location
D1
D2
D3
D4
GORTADROMA
Gort an Droma
Sand Pit
Burial Ground
(Disused)
Gravel Pit
Castle
White River
Limerick
Limerick County Council
Project
Gortadroma Landfill Extension EIS
Title
Dust Monitoring Locations
Figure 1
RPS mcos
Carnegie House
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Issue Details
Drawn: CW
Checked: SK
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Drawing No. MI0133
Rev. A01
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The method used is the Bergerhoff dust gauge that comprises a plastic container supported on a metal pole, to collect bulk particulate material. The container has an opening of 0.089m, with a collection area of $0.0062m^2$ and material falling into the container is collected after exposure over a month and analysed using the German Standard procedure (VDI 2119) for determination of dustfall amounts. The method includes both soluble, ie. dissolved salts present in rainwater, as well as undissolved material such as particulate material and biological debris. The dust deposition limit specified in Schedule C of the Waste Licence 17-2 is 350 mg/m^2.day, expressed as a monthly average over a 30-day period.

Table 1
Dust deposition rates at site boundary (mg/m^2.day)

Location	Survey Period		
	14/11/00-14/12/00	28/6/01-26/7/01	4/7/02-1/8/02
D1	95	6	58
D2	65	15	46
D3	65	19	66
D4	57	42	108

The results of the dust deposition survey during the past three annual periods indicate that measured deposition rates are less than 31% of the emission limit specified in the licence.

3.1.2 PM_{10}

Monitoring of ambient particulate concentrations at the site boundary is undertaken over a 24 hour period on an annual basis at the 3 locations used for the dust deposition survey. The survey measures PM_{10} (particulate material with a mean diameter of < 10 µm) as required under Schedule F of the licence. This survey is carried out by drawing $24m^3$ through a PM_{10} sampling head and collecting the particulates in the sample air on a quartz fibre filter paper. The mass of particulates present on the filter paper is subsequently determined by standard gravimetric procedures in the laboratory using a micro-balance and the concentration expressed as microgrammes per cubic metre ($\mu g/m^3$)

Table 2
PM_{10} levels at site boundary ($\mu g/m^3$)

Location	Survey Period		
	Dec 2000	July 2001	July 2002
D1	8	25	12
D3	8	13	29
D4	8	21	17

A daily average PM_{10} trigger value of 50 $\mu g/m^3$ is specified in Condition 6.6 of the Waste Licence, which if exceeded requires remedial measures to be carried out to reduce emissions of particulates. None of the locations exceeded this trigger value with the maximum concentration 58% of the value. Due to the short-term nature of the monitoring programme, no comparison can be made in relation to compliance with the future National Air Quality Standards.

3.1.3 Odours

3.1.3.1 Overview

Malodorous compounds generated within a landfill include hydrogen sulphide, organic sulphides (mercaptans), amines and other volatile organic compounds, some of which have very low odour detection levels. These compounds are generated during the anaerobic decomposition of the waste deposited in the landfill cells and when they are released to the atmosphere from borehole vents and other sources can result in highly pungent malodours within a landfill.

Ambient surveys of malodorous trace gaseous compounds at a landfill can be carried out using two approaches, by collecting an air sample and deriving the odour concentration or by sampling for specific chemical compounds and determining the ambient concentrations. The odour concentration is determined by a small sample of persons in a laboratory using an olfactometer and the results are expressed in terms of odour units per m^3 (o.u./m^3). An odour concentration of 1 o.u./m^3 is the level at which there is a 50% probability that, under laboratory conditions using a panel of qualified observers, an odour may be detected. At levels below 1 o.u./m^3 the concentration of the gaseous compound causing the odour in the air will be less than the detection level and so although the odorous gas is still present in the air no odour will occur. If an odour concentration in the ambient air sample is determined to be above about 5 o.u./m^3 then nuisance complaints are possible, with strong complaints likely above 10o.u./m^3. This method provides a relative measure of the level of malodour experienced in the locality. However it does not provide information on the concentrations of certain odorous gases present and so cannot be related to likely exposure health risk to the local community.

Chemical sampling provides information on the concentration of different chemical species present and so the results can be compared with published odour threshold data or health exposure limit values. However, there are substantial difficulties in identifying certain odorous volatile organic compounds in ambient air within a landfill due to the low concentrations normally present, even though they may contribute to much of the odour pungency experienced. The odour detection threshold of some trace gases is well below 0.1 μg/m^3 and so although strong malodours may be present; the ambient concentration could be less than 1 μg/m^3. This concentration is still below the analytical detection level of standard analytical equipment. In the case of H_2S the odour detection threshold is reported to be slightly higher with reported range of 0.2-2 μg/m^3 (published best estimate average of 0.76 μg/m^3), with a recognition threshold of 0.6-6 μg/m^3.

Measured concentrations even within a landfill environment are normally well below those experienced in an indoor workplace due to rapid dilution in the ambient air of emissions. In the indoor workplace environment, volatile organic compounds are typically measured in milligrammes per cubic metre (mg/m^3) or parts per million (ppm) rather than at the microgrammes per cubic metre (μg/m^3) or parts per billion (ppb) level normally found in ambient air. Therefore, the sampling time should be for an hour or longer to allow a sufficient quantity of air to be sampled on the collection media. The limit of detection (LOD) for the analytical procedure is also crucial since a low limit is necessary to identify and quantify concentrations of certain trace compounds. However, longer sampling times will not provide information on concentrations exposed to during peak concentrations when an odour nuisance may be reported.

3.1.3.2 Surveys

As part of the ongoing environmental monitoring a programme of odour monitoring involving regular inspection of certain boundary locations by staff and recording details of complaints reported by nearby houses is carried out. An effective qualitative odour survey can be carried out by using the 'sniff' sampling approach where a member of staff walks around the site boundary to identify if odours are present. Although somewhat subjective, as no air sample is collected, it still enables the categorising of malodours near the site boundary in broad terms; for example none, slight, moderate, pungent etc. In addition, based on the experience of the personnel it may be possible to characterise the malodour with a particular type of source within the landfill. For example 'sweet' ester odours are associated with recently tipped domestic waste whereas the pungent smell of 'rotten eggs' could be caused by recent spreading of sewage sludge within the cell.

The boundary survey is carried out at Gortadroma four times a day (8.00,11.00,14.00 and 16.00). Five locations are inspected, coinciding with the direction towards the nearest houses as well as at the site entrance. Prior to September 2003, the survey was undertaken twice per day and an assessment of the daily log sheets indicate that where odours were detected they were categorised as slight with no major events reported in recent months. The registering of odours at the boundary locations was also more frequent during the morning inspection compared to the evening visits

In addition, as part of Condition 8.11 of the Waste Licence, a monthly log is also kept of all nuisance complaints by the local community (including details of location, nature of odour complaint, times and weather conditions). The monthly registers indicate that during 2003 there has been a substantial reduction in the number of reports of malodours at the houses to the west, northeast and west of the landfill boundary. There were a total of 22 reports of complaints to the site office between June and September 2003, compared to 47 during the preceding 4-month period. During September 2003, there were only 2 complaints.

The nature and extent of the malodour has been the subject of an extensive investigation within the landfill in recent months to identify and if possible eliminate the emission source. The original flare-stack installation has been replaced by a larger unit, capable of burning twice the volume of landfill gas and this has helped to reduce the incidence of malodours at the boundary. In addition, provision of additional boreholes in the gas collection network on the capped part of the landfill has improved collection efficiency and helped to maintain negative pressure within the cell. These recent measures have resulted in a reduction in the incidence of complaints by local residents.

During the site visit undertaken as part of the EIS report in June 2003, malodours consistent with landfill gas were identified on the walkover near the capped area of the existing landfill. However, no malodours could be detected along the roads running near the western and northern site boundary. A subsequent independent short-term survey using an H_2S field monitor, capable of measuring concentrations below 1ppb, was carried out in June 2003. At all the monitored locations around the site boundary, the ambient levels were below the analytical detection level of the equipment.

Due to the nature of the activity at Gortadroma, it is not possible to eliminate all sources of malodours from the landfilling operation. However, with ongoing improvements being made to reduce and contain potential malodorous emission sources the potential for nuisance complaints at nearby houses will decrease. This trend is evident from a review of the records of odour complaints kept by the site office that the incidence of malodours is decreasing, in particular as a result of the improvements recently made to the gas collection system. Reported odours also tend to be slight in magnitude and transient in duration when experienced within the local community.

3.1.4 Sulphur dioxide and Nitrogen oxides

Ambient concentrations of sulphur dioxide and nitrogen dioxide in the vicinity of the landfill will be similar to those recorded in rural locations elsewhere in Ireland and well below the existing National Air Quality Standards (NAQS) (SI: No 244 of 1987). They would also be well below the more stringent future limit values specified in the Air Quality Standards Regulations 2002 (SI No 271 of 2002). These limit values are based on the requirements contained in the 1999 E.U. Air Quality Directive (1999/30/EC). The 2002 Regulations gives a daily limit value for sulphur dioxide of 125 $\mu g/m^3$, expressed as a 99.2 percentile (4^{th} highest daily value of the year) and an hourly value of 350 $\mu g/m^3$ (25th highest value over a year). These limit values are to be met by 2005. The corresponding limit values for nitrogen dioxide are 200 $\mu g/m^3$ as an hourly 99.8 percentile (19th highest hourly value over the year) and an annual limit of 40 $\mu g/m^3$. These limit values are to be met by 2010.

Ambient concentrations of sulphur dioxide would be very low and typical of measurements obtained in rural locations in Ireland. There are no significant emission sources of sulphur dioxide in the area, as householders in the locality would be burning either low-sulphur distillate oil or peat. Diesel fuel used by road vehicles also has a very low sulphur content. Maximum daily sulphur dioxide concentrations would be generally below 10 $\mu g/m^3$ and so well below 10% of the current and future NAQS.

A 6-week survey of nitrogen dioxide using passive diffusion tube sampling techniques was carried out in 1997 for the first EIS application. This method of ambient sampling is a recognised procedure for establishing ambient concentrations of nitrogen dioxide in both urban and rural environments and is widely used in Ireland and the U.K. The nitrogen dioxide present in the air diffuses along the acrylic diffusion tube where it is absorbed onto an impregnated stainless steel mesh located at one end. The concentration is then determined in the laboratory using ultra-violet colorimetry. The results of the survey undertaken at two locations, one on the public road to the east of the site and other adjacent to the landfill entrance, indicate ambient concentrations were very low and between about 4-7 $\mu g/m^3$. Compared to the future annual NAQS of 40 $\mu g/m^3$ the ambient levels near the landfill were below 25% of this limit value. Present ambient nitrogen dioxide concentrations would be similar to those obtained in 1997, due to the rural nature of the site and the low level of traffic in the locality.

3.2 Climate

3.2.1 General

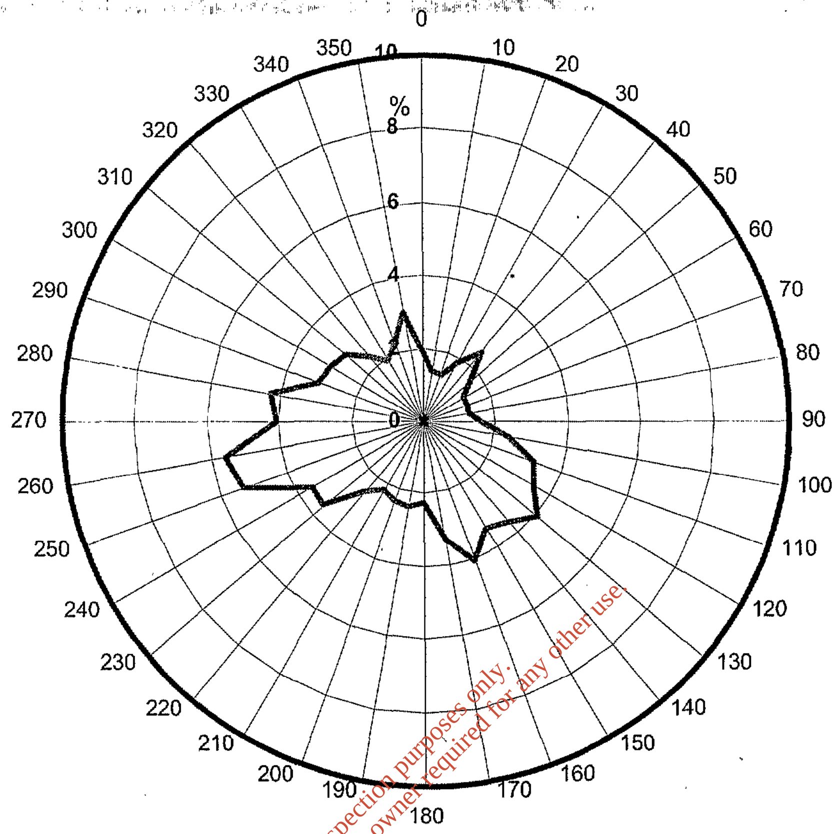
The climate of the Co. Limerick region is characterised by the frequent passage of Atlantic low pressure weather systems and associated frontal rain belts from the a westerly direction, especially during the winter period. Over the summer months the influence of anticyclonic weather conditions can result in drier continental air, in particular when winds are from the east, interspersed by the passage of Atlantic frontal systems. Occasionally, the establishment of a high pressure area over Ireland and Britain will result in calm conditions and during the winter months these are characterised by clear skies and the formation of low level temperature inversions with slack wind conditions at night-time. Prolonged dry weather conditions are relatively infrequent but should continental air masses dominate over Ireland a period of drought conditions may occur which could last up to 2 or 3 weeks.

The local climate is an important factor in determining the magnitude and direction of maximum air quality impact due to atmospheric emissions from the operation of the landfill facility at Gortadroma. The wind speed will affect the rate of dilution of emissions from the various emission sources of dust, PM_{10} and gaseous compounds generated within the landfill. The precipitation pattern of the locality affects the generation of leachate within the landfill and so contributes to the decomposition of waste matter in the cell. It is also important in controlling emissions of dust and PM_{10} from the road surfaces.

3.2.2 Wind

Fugitive dust emissions from a surface occur if the winds are sufficiently strong and turbulent and the surface dry and loose to cause re-suspension from the ground and road surfaces. The surface needs to have a relatively low moisture content for this type of dust emission to take place and any wetting, either by rainfall or sprayers, will greatly reduce the potential for fugitive dust emissions to take place. A wind speed at ground level in excess of about 5 m/s is considered to be the threshold above which resupension of fine sized material from an exposed surface may take place.

Long-term results from Shannon Airport meteorological station (approx. 20km to NE) over a 15 year period indicate that the prevailing wind direction is from the SW-W with an annual incidence of about 30% **(Fig 2).** The lowest frequency is for winds from a direction of 30-90 degrees, i.e. from the NE-E direction. The incidence of winds greater than 5m/s is about 36% of the year. The mean annual wind speed is 5.2m/s, with about 1% of hours recording a speed of below 1m/s.



HOURLY WIND DIRECTION FREQUENCY - ALL WIND SPEEDS

Direction	Percentage Occurrence of Wind Speeds (m/s)					
	<2	2-3	4-5	6-8	>9	All
350-10	1.22	1.83	1.92	0.86	0.11	5.94
20-40	1.31	1.37	1.36	0.83	0.09	4.94
50-70	0.96	0.73	0.85	0.61	0.03	3.18
80-100	0.77	0.82	1.17	0.73	0.24	3.73
110-130	1.80	3.48	3.58	1.85	0.46	11.17
140-160	1.11	1.61	3.15	3.41	1.23	10.51
170-190	0.63	1.46	2.94	2.76	1.00	8.80
200-220	0.73	1.45	2.59	2.32	0.84	7.94
230-250	0.90	1.64	3.59	4.82	2.83	13.79
260-280	1.15	2.13	3.65	4.10	2.58	13.60
290-310	1.14	1.56	2.24	2.43	1.13	8.49
320-340	1.69	2.16	1.94	0.88	0.21	6.89
Calms	1.02					
Total	**14.43**	**20.25**	**28.97**	**25.60**	**10.75**	**100.00**

FIG 2: FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR HOURLY OBSERVATIONS AT SHANNON AIRPORT (1995-00)

3.2.3 Rainfall

Annual rates of precipitation in the Gortadroma area are generally between about 1000-1250mm with the months of October-January normally receiving the greatest monthly rates. The local rainfall pattern is important as it affects the moisture content of the surface of internal haul roads and hence potential for fugitive dust emissions from the road surface.

The nearest climatological station with long-term daily rainfall rates is situated in Shanagolden (approx. 5km to NE) and the long term results for the period 1960-94, along with those for each of the years 1994-97 and long term daily rainfall extremes are shown in Table 3. The results indicate long-term monthly mean precipitation rates ranging from 68-125mm with some monthly totals reaching 169mm. The long-term (1960-94) daily maximum total at Shanagolden has ranged from 203-253mm during the winter months and 158-199mm during the summer period. During the winter the rainfall will be commonly associated with Atlantic frontal depressions whereas during the summer months high rainfall amounts will tend to be associated with intense thundery showers which may be localised in rainfall intensity.

Table 3
Precipitation rates at Shanagolden climatological station, (mm)

Period	J	F	M	A	M	J	J	A	S	O	N	D	ann
(1)Mean 1960-94	119	88	86	62	68	72	69	88	91	112	114	125	1095
(2)1994	-	-	-	-	-	-	60	88	77	89	70	225	-
(2)1995	250	219	146	34	85	27	67	7	75	115	112	86	1225
(2)1996	96	134	99	61	54	26	63	86	41	157	161	29	1009
(2)1997	35	169	28	34	73	132	62	-	-	-	-	-	-
(1)Daily max 1960-94	207	253	177	170	184	167	158	197	199	205	203	215	253
(1)Daily min 1960-94	20	4	21	16	16	23	13	14	19	46	44	41	4

Note: (1) - Shanagolden Voc School (1960-94 now closed), (2) Shanagolden Old Abbey (1994-)

3.2.4 Air Temperature

The pattern of long-term daily temperatures at Shannon Airport (1951-80) which is the nearest location where these data are available are shown in Table 4.

Table 4
Long-term daily air temperature at Shannon Airport (1951-84)

	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Mean	5.4	5.4	7.0	8.8	11.3	13.9	15.4	15.2	13.5	11.0	7.6	6.3	10.1

4.0 IMPACT OF PROPOSED LANDFILL EXTENSION

4.1 General

Atmospheric emissions from the operation of the proposed landfill extension at Gortadroma may be categorised as continuous or fugitive (short-term due to the execution of a specific activity). The types of sources are as follows: -

1) Area sources include uncontrolled landfill gas emissions from fissures in completed cells and emissions from recently tipped waste in operational cells. These areas of the landfill will be sources of dust and volatile organic compounds. The latter type of emissions can be highly odorous. The contribution of these types of sources to total VOC's from a landfill will depend on the efficiency of any installed gas collection system.

2) Line emission sources are the emissions generated from trucks and other vehicles travelling along the access and internal haul roads to the tipping area. Depending on the road surface conditions, fugitive dust and PM_{10} emissions caused by the re-suspension of particulates from the road surface by the vehicles travelling along the road may be significant. If the volume of road traffic is relatively low, with only a small number of trucks travelling along a road during the day, then dust-blow is likely to be short-term and intermittent and so may be referred to as fugitive emissions.

3) Point sources are specific emission points within the landfill extension and include uncapped boreholes and landfill gas flare stack, or generating plant exhausts. These types of emissions tend to be relatively continuous. Emissions associated with such sources are typically VOC's, methane and inorganic gases associated with landfill gas.

The types of air pollutants emitted from the landfill can be grouped under the following headings:-

- Dust and PM_{10}
- Aerosols
- Odours
- Landfill Gas

4.2 Dust and PM_{10}

Emissions of dust and PM_{10} will occur within the landfill extension from trucks travelling along the access and internal haul roads and from tipping the waste material into the designated areas. Generally, trucks travelling along internal loosely surfaced (unpaved) haul roads are the main source of dust within a landfill. The action of the wheels moving along the surface generates resuspension of loose material from the road surface. A hard-paved road surface such as asphalt or concrete or compacted rock chippings, substantially reduces the potential for dust emissions compared to an unpaved surface, which are normally covered with accumulations of silt and other loose material. The emission rate of dust from a road surface depends on the type of surface cover, the speed of vehicles and the weight of the trucks travelling along the road.

During dry weather conditions, the haul roads will be sprayed with water from a mobile tanker to control dust emissions. The use of water sprays on roads in the facility is required under Condition 6.11 of the existing Waste Licence. In the winter months, the surface is likely to be sufficiently damp from rain for much of the time so that spraying is not necessary. However, with higher air temperatures and periods of dry weather more frequent in the summer months, spraying the road surface with water is likely to take place on a regular basis. Typically, a wind speed above 5m/s will result in significant dust-blow from the road surface and the rate of re-suspension of material will increase as the wind speeds rises. Hard paved or asphalt road surfaces have a much lower emission rate compared to unsurfaced roads.

Estimates of emissions from road surfaces and tipping of waste have been made based on the emission factors published by the U.S. Environmental Protection Agency (AP-42 Volume 1, 1998). The procedures allow emission rates in terms of g/VKT (grammes per vehicle kilometre travelled) to be calculated for different types of road surfaces and also a value can be derived based on the quantity of waste being deposited.

The average number of trucks/skips per day entering the facility when the proposed extension is in operation is about 35 (equivalent to 70 vehicle movements per day). Cars/vans depositing waste will not be permitted to enter the extension area and will be restricted to the civic amenity disposal area near the site office/weighbridge. In any case, these smaller vehicles generate much lower quantities of dust compared to larger 20 tonne articulated or 12 tonne compactor vehicles travelling along internal unpaved roads. The emission factor has been adjusted to take the vehicle composition into account. For paved or macadam roads, the emission rate was estimated to be in the order of 0.001 g/s per VKT and 0.01 g/s for unpaved roads. The total maximum emission rate from vehicle movements within the landfill site was calculated to be about 60 kg/day (0.7 g/s), based on a road length of 1km and under dry weather conditions with no dust control measures.

Emissions of dust from the tipping area are normally minor in comparison to total emissions from a landfill. The disposal of ordinary domestic waste in plastic bags substantially will reduce the quantity of loose refuse that could create visible clouds of dust. The compaction process mixes the waste material and so tends to bind the smaller particulate size fractions in the refuse and so emissions of dust are reduced. Covering of the freshly deposited waste takes place daily with a hessian sheeting and so dust emissions from the active cell area will be very low. Fine-sized materials such as waste cement, plaster etc. may occasionally be disposed along with the standard municipal waste and this can generate substantial short-term dust emissions as it is deposited.

Current levels of waste material deposited at the landfill on a daily basis are estimated to be about 300 to 400 tonnes for 2003. This waste includes a high fraction of municipal waste in refuse bags with a relatively low proportion of loose waste material. The emission rate at the tipping zone, was estimated to be about 0.1 kg/day. Overall, emissions of dust and PM_{10} from tipping waste within the extension area are predicted to be minor and typically less than 1kg/day.

Emissions generated during the tipping of waste and compacting will be below the top of the boundary berm around the edge of the disposal cell and so this feature of cell design will act as a barrier to dust emissions released within the cell. In addition, there will be a substantial reduction in dust and PM_{10} emissions from the haul road by spraying the surface with water using a mobile tanker during dry weather conditions. The derived dust and PM_{10} emission rates tend to represent 'worst-case' maximum levels that can occur under dry weather conditions without active dust suppression. Overall, the emissions of total airborne particulates from tipping waste are predicted to be minor. Particulate emissions from areas within the landfill facility where areas of bare soil has stabilised under natural weathering or vegetation is growing, such as on the slopes of the completed capped cells and boundary bund will not be significant.

With the implementation of the dust measures outlined in Section 5 emissions of dust and PM_{10} will be adequately controlled within the landfill facility. The results of dust and PM_{10} monitoring obtained from the present network indicate that there is no significant impact on air quality beyond the site boundary due to these emissions from the landfill operation.

4.3 Aerosols

Aerosols are defined as fine particulate material, water droplets and microbial emissions from the activities carried out at the landfill. They are typically particles which remain airborne for a reasonable length of time and generally range in size from less than 0.1 μm to about 100 μm. Small sized particles, including PM_{10}, have potential health implications, as they may be inhaled and enter the lower respiratory tract. Airborne particles greater than about 30-50 μ m will tend to remain airborne for only a few tens of metres downwind of the emission source, whereas the finer-sized fraction can travel a significant distance under windy conditions.

The primary sources of particulate aerosols within the proposed landfill extension will be from the haul roads; especially unpaved sections or where silt has accumulated on the road surface. The impact of these emission sources is dealt with in the previous section. Emissions of liquid droplet aerosols will occur from the leachate treatment plant, which provides biological treatment, secondary and tertiary treatment. The biological treatment comprises an open activated sludge tank with surface aeration. The surface aeration process will generate droplet aerosols which will be dispersed downwind of the treatment plant.

Close contact with aerosols from landfill refuse or leachate will increase the risk of certain infections due to the presence of various microorganisms present in the refuse/clay material. These could present a health risk for on-site workers, if certain health and safety conditions are not enforced. However, the risk of infection within the local community due to aerosols from the landfill dispersing downwind is very low. Based on the proposed operation of the landfill extension including improvements in dust control measures and covering refuse on a daily basis no significant impact on the health of the local community or environment is predicted.

4.4 Odours

Odours from a municipal landfill are caused by certain trace organic and inorganic compounds generated within the landfill during the waste decomposition stage. The Environmental Agency in the UK has identified over 500 trace organic and inorganic compounds generated from deposited municipal waste. However only a small number of these compounds are likely to cause a potential odour problem at ambient concentrations experienced beyond the site boundary. Some of these trace gases may be less than 0.00005% of the total landfill gas volume. However, in the case of organo-sulphur compounds such as mercaptans, dimethyl sulphide as well as hydrogen sulphide, these compounds are highly pungent with extremely low odour detection thresholds. Sulphurous compounds are generated during the anaerobic decomposition of the waste deposited in the landfill cells and when they are released to the atmosphere from borehole vents and other sources can result in highly pungent malodours within a landfill. Mercaptans and dimethyl sulphide have odours typically characteristic of rotten vegetables/garlic and hydrogen sulphide has the characteristic odour of 'rotten eggs'.

The impact of odours on the ambient air quality will depend on the emission rate, the distance downwind to the sensitive receptor location and the dispersive properties of the lower air layers. The distance downwind at which the 'odour detection' concentration is reached may be within a few metres of the odour source if the rate of emission is low or a considerable distance if the emission rate is very strong. The wind speed and direction are also major factors in determining whether emissions from the landfill will cause a community nuisance beyond the site boundary.

The management of the proposed landfill extension includes daily cover of compacted waste and this significantly reduces the potential for malodorous emissions from the surface of the active cell. The cells will be lined with an HDPE liner with a gas collection network also installed as the cells are developed. The liner will prevent lateral migration of landfill gas and so reduce the emissions of malodorous gases beyond the boundary of the landfill cell. Collecting the gas generated within the cells and burning this gas in a flare-stack or energy utilisation plant will reduce the potential for malodours from the landfill being experienced beyond the site boundary (Section 4.5.3).

The impact on air quality due to odorous emissions from the proposed landfill extension is predicted to be slight in the vicinity of the site. The present incidence of reported malodours at houses near the western and northern site boundaries should continue to decline, with the planned improvements in the operation of both the existing area and landfill extension. Continuing identification of potential odour emission hot-spots and the extension of the gas collection network will further reduce the incidence of malodours being detected beyond the site boundary.

4.5 Landfill Gas

4.5.1 Introduction

Landfill gas is the primary component of air emissions from a landfill site both during its operation and also after the cells have been completed and capped. The main constituents of landfill gas are methane (CH_4), carbon dioxide (CO_2), oxygen, nitrogen and hydrogen (Table 5). Methane and CO_2 typically comprise over 97% of the total volume of the overall gas, both of which are odourless. There are a wide range of volatile and semi-volatile organic and inorganic components which are present in trace amounts and typically represent less than 1% by weight, with concentrations in the gas at parts per million (ppm) or parts per billion (ppb). These trace constituents, in particular mercaptans and nitrogen based compounds (amines), along with hydrogen sulphide give the distinctive pungent odour of landfill gas.

The typical composition of landfill gas is given in Table 5 and it is evident that over 99% of the gas volume is comprised of methane, carbon dioxide and nitrogen with the remainder consisting of a large number of trace gases.

Uncontrolled landfill gas emissions from the surface of a landfill are dependent on the gas production rate and degree of lateral and vertical migration. Vertical movement involves the migration of the gas to the surface of the landfill, through the air layer in contact with the surface and into the atmosphere by diffusion and convection by solar heating of the ground and wind over the surface. Capping the surface with clay and covering with top-soil can substantially reduce vertical diffusion of landfill gas from the surface of the completed cells.

Table 5
Typical composition of a landfill gas

Component	Typical vol (%)	Max vol (%)
Methane	63.8	88.0
Carbon Dioxide	33.6	89.3
Oxygen	0.16	20.9
Nitrogen	2.4	87.0
Hydrogen	0.05	21.1
Carbon Monoxide	0.001	0.09
Ethane	0.005	0.0139
Ethene	0.018	-
Acetaldehyde	0.005	-
Propane	0.002	0.0171
Butanes	0.003	0.023
Helium	0.00005	-
Higher Alkanes	<0.05	0.07
Unsaturated Hydrocarbons	0.009	0.048
Halogenated Hydrocarbons	0.00002	0.032
Hydrogen Sulphide	0.00002	35.0
Organosulphur compounds	0.00001	0.028
Alcohols	0.00001	0.0127
Others	0.00005	0.023

Source: U.K. Dept of Environment Waste Management Paper No 27 (1989)

The dominant source in terms of potential health risk is where large uncontrolled surface emissions of landfill gas occur within confined areas of a site. However, although the gas is highly odorous, emissions from a landfill are unlikely to result in significant ambient concentrations of individual trace compounds beyond the site boundary. Dilution rates of several hundred times are normally available above the surface of a landfill cell, even during slack wind conditions. The distance to the boundary of the landfill will result in a further substantial reduction in the ambient concentration due to natural dispersion mechanisms.

4.5.2 Landfill gas recovery and emissions

A landfill gas collection system has been installed to connect the numerous boreholes within the capped area of the present landfill to a flare stack installation near the centre of the site. Surveys have been undertaken to identify landfill gas emission hot-spots as part of the gas management programme for the site. The gas collection network installed within the planned extension area will be linked into the overall site network. When landfill gas has been generated within the cells in the extension area, it will also be burnt in the flare stack or used to generate electricity in a gas to energy utilisation plant.

Landfill gas collection efficiencies for a municipal landfill can typically vary significantly, from less than about 50 to 85%, depending on the extent of the pipeline collection system installed to extract the gas from the cells. Where the cells are unlined there are normally high losses to atmosphere from lateral migration as well as vertical diffusion through fissures in the completed cell capping which will greatly reduce the effectiveness of a gas collection/flare system. However, the new cells will be lined and so uncontrolled losses through lateral migration and venting to atmosphere from fissures in the ground will be greatly reduced.

When landfill gas is flared, or burnt in an energy utilisation plant, removal or destruction efficiency rates of Non-Methane Volatile Organic Compounds (NMVOC's) are generally in the order of 85-99.5%. This will result in the concentrations of trace compounds in exhaust gases of less than 1% of the levels found in the original landfill gas presented in Table 5 above. Other pollutants present in flares are methane, nitrogen dioxide, carbon monoxide, sulphur dioxide, water vapour and carbon dioxide. The concentration of these pollutants in the emissions from the flare-stack depend on the design of the flare burner or energy utilisation plant characteristics, such as burner flame temperature, gas flow rate, moisture content of feed gas etc. The presence of other compounds including sulphur, chlorine and fluorine compounds in the exhaust gas largely depends on the quality of the landfill gas being flared.

Table 6
EPA emission limits values for landfill gas flare-stack

Substance	Conc (mg/Nm^3)
Carbon Monoxide	50
Nitrogen Oxides (as NO_2)	150
Hydrofluoric Acid	5 (at mass flows > 0.3 kg/h)
Hydrochloric Acid	50 (at mass flows > 0.05 kg/h)
Total Volatile Organic Compounds (VOC's) (as C)	10

Note: Waste Licence 17-2, Schedule C (Table 5). Emission Limits; Reference Level 3% oxygen

The existing landfill gas flare installation is designed to operate in accordance with the latest flare-stack developments and comply with the emission limits specified by the EPA in the Waste Licence 17-2 Schedule C (Table 6). The flare-stack is an enclosed or 'shrouded' flare unit, with a stack height of 7m and the gas is burnt at a minimum flame temperature of 1000 ^{o}C and retention time of 0.3 seconds. An enclosed flare provides a higher degree of controlled combustion than is experienced with open flare installations. The combustion air is controlled and the shroud containing the burner is well insulated to maintain a high combustion temperature. A high level of destruction of the organic and inorganic compounds present in the gas feed is achieved with the high flame temperature. Rapid dilution of the emissions from the stack due to the buoyancy of the hot exhaust plume will result in the pollutants in the plume being well dispersed by the time they reach ground level downwind of the stack.

Within 12 months of the granting of the Licence 17-2, Condition 3.13.1(c) requires that the landfill gas is burnt in an energy utilisation plant to generate electricity, instead of flaring the gas. The emission limits specified for the energy utilisation plant are given in Table 7.

Table 7
EPA emission limits values for energy utilisation plant

Substance	Conc (mg/Nm^3)
Carbon Monoxide	1400
Nitrogen Oxides (as NO_2)	500
Particulates	130
Total Volatile Organic Compounds (VOC's) (as C)	1000
Total non-methane VOC's (NMVOC's)	75
Hydrofluoric Acid	5 (at mass flows > 0.3 kg/h)
Hydrochloric Acid	50 (at mass flows > 0.05 kg/h)

Note: Waste Licence 17-2, Schedule C. Emission Limits; Reference Level 5% oxygen

A requirement of the Waste Licence will be that exhaust emissions from the gas flare-stack or electricity generating plant do not exceed the stringent emission limits given in Tables 6 and 7. With the gas collection system linked to the flare stack or proposed electricity generating plant, emissions of landfill gas from the site will be dramatically reduced, compared to the scenario where emissions are uncontrolled. It is likely that landfill gas will be produced at Gortadroma Landfill for a period of at least 20-30 years, depending on the future site operating conditions and so long-term controls and monitoring are therefore required.

4.5.3 Impacts on the local environment and community health

There is no scientific evidence providing a causal link between emissions of landfill gas and significant adverse impacts on the flora/fauna, livestock and community health in the locality of properly managed municipal landfills. A detailed review of published studies was carried out recently by the Health Review Board (Health and Environmental Effects of Landfilling and Incineration of Waste, 2003). This report concluded that "although a great number of studies have been carried out, evidence of a causal relationship between specific health outcomes and landfill exposure is still inconclusive". No evidence to demonstrate a clear link between cancer, respiratory, skin or gastro-intestinal illnesses and exposure to emissions of landfill gas was found.

Risk to ill health is related to the concentration of pollutant present at a particular location and the length of exposure; in other words, the dosage experienced by an individual. An ambient air quality survey was undertaken in June 2003 of NMVOC's and hydrogen sulphide at 9 locations at the site boundary and nearby resident locations. The NMVOC's compounds measured have been identified by the Environmental Agency in the UK as priority trace components, based on their toxic or odour properties. The results of this survey indicate that observed concentrations were less than 1% of occupational health standards established by the Health and Safety

Executive in the UK. Indeed, many of the compounds measured were below the analytical detection level for the test method used.

In terms of potential toxic health effects from air pollutants emitted from a flare-stack or a future electricity generating plant exhaust, it is continuous, long-term or annual exposure, which is important. Although short-term peak ground level concentrations can occur downwind of the flare stack, the potential health impacts will be negligible due to the small period of exposure. Long-term impacts due to the flaring or utilisation of the landfill gas will result in ground level concentrations within the locality well below those associated with a significant impact on human health or adverse impact on the environment.

Atmospheric emissions and consequently possible health risks will decline further with improvements in the landfill gas collection, flaring or future energy utilisation. Due to the nature of the waste handling operation carried out at Gortadroma it is impossible to eliminate all incidents of malodours being occasionally detected beyond the site boundary. However, continuing improvements in the management of the site will help to reduce the incidence when malodours from the waste facility are detected beyond the site boundary. The measures should ensure that such impacts on local air quality are short-term and infrequent with no significant impact on local community health. With regard to emissions from the flare-stack or energy utilisation plant, the impact on air quality is predicted to have a slight or imperceptible impact on the local ambient air quality with no significant health effects within the local community.

4.5.4 Contribution to Greenhouse gases

Under the 1997 Kyoto Protocol on Climate Change, Ireland agreed to limit an increase in its greenhouse gas emissions to 13% above 1990 levels in the period 2008-2012. An even more ambitious strategy to reduce National green house gas emissions by over 20% in the next ten years has been set under the National Climate Change Strategy. Methane is one of the principal greenhouse gases. Based on National emission estimates for 1998 published by the EPA, methane emissions were approximately 649,000 tonnes/year with about 88% originating from agricultural sources and 12% or 76,000 tonnes from solid waste landfill disposal.

The annual rate of landfill gas generated in the Gortadroma landfill is calculated to be about 17 x 10^6 m^3 in 2003. The volume of gas generation is based on the GasSIM model used to simulate the rate of gas production at the landfill and the potential for generating electricity in an utilisation plant. The projections indicate a maximum gas generation rate of 26 x 10^6 m^3 in 2020 declining to 4.2 x 10^6 m^3 by 2030. Assuming a methane composition of 65% of the landfill gas volume, with 10^3 m^3 equivalent to 714 kg of methane (derived from the molar weight, 1 mole= 22.4 l = 16g), this equates to about 7,900 tonnes in 2003. By 2020, the methane generation rate is projected to increase to about 12,100 tonnes per year. Thereafter, it is projected to decrease rapidly. Compared to the National total for methane emissions the rate from the landfill is equivalent to about 1% in the event that emissions were uncontrolled. Therefore, with the gas collection system in place at Gortadroma methane emissions will be substantially lower and well below 1% of the estimated National total emission rate.

The National Climate Change Strategy estimate that a substantial reduction of 50% in methane emissions from landfills can be achieved by flaring (converting the methane to carbon dioxide), or used to produce electricity. With the installation of the gas collection network and flaring or burning it in the energy utilisation plant, emissions of methane and other greenhouse gases will decrease dramatically from the waste facility. These local measures will help meet the target of reducing methane emissions to 60% below the 1990 levels from the waste sector in Ireland by 2010.

4.6 Closure of the landfill extension

The cells in the extension area will be filled, capped and graded to prevent malodorous emissions and ground cover vegetation will be re-instated to control dust emissions from the surface. Landfill gas from the completed cells will be collected and burnt to generate electricity in a gas utilisation plant.

5.0 MITIGATION MEASURES

The operation of the landfill extension will be carried out in accordance with the requirements specified in Condition 6 of the current waste licence with regard to controlling and reducing atmospheric emissions. The measures to control and reduce emissions include:-

- Tipping of waste material shall be controlled within the landfill extension.
- Waste material will be covered daily with hessian sheeting or suitable inert material, such as stone, rocks, bricks, crushed concrete etc., to control emissions of dust and malodours from the surface of the active cell. At the end of each week, the tipped material will be covered with a layer of inert material, with a minimum depth of 150mm.
- When the surface of the cell has reached the design height it will be capped, restored and re-seeded with grass.
- Burning of any waste material on-site shall be prohibited.
- Sewage sludge will be deposited by spreading over a small designated area and promptly covering with inert material. Where practicable, disposal should not take place during poor (wind) dispersal conditions.
- Mobile plant equipment used on-site will be regularly maintained to prevent excessive exhaust emissions of particulates and other pollutants.
- Haul roads within the landfill extension will be covered with compacted hardcore to reduce dust emissions from trucks travelling to and from the tipping area.
- The public road near the entrance to the landfill and hard-paved road surfaces within the site reception area will be maintained to ensure any spillages of material from vehicles entering or leaving the site will be promptly removed to reduce dust emissions from the road surface.

- A mobile water sprayer will be employed during dry weather conditions to reduce dust emissions from the access road and haul roads within the landfill site.

- All trucks departing from the site will pass through the existing wheel wash, which shall be maintained with the silt removed on a regular basis.

- All boreholes will be capped and inspections carried out at regular intervals to inspect the completed cells for leaks and uncontrolled venting of landfill gas.

- Regular inspections will be carried out of capped areas to identify and eliminate, where practicable uncontrolled emissions of landfill gas

- Landfill gas generated from the completed cells will be collected and piped to the flare-stack installation or future energy utilisation plant.

6.0 IMPACTS AND MITIGATION DURING THE CONSTRUCTION PHASE

6.1 Impacts

The new cells are to be constructed on a phased basis as the landfill extension is developed. The peat will be excavated and this material will be deposited in a number of designated areas to the NE, E and S of the filling area, within the buffer zone around the site. Approximately 40% of this material will be used on a progressive basis for capping the completed cells, with the remainder used for the boundary berm and landscaping.

Dust emissions will occur in dry weather conditions during the construction phase as a result of the movement of overburden, boundary bund and cell construction and also from machinery travelling along the temporary haul roads within the extension area. On-site construction equipment will comprise heavy earth moving equipment, including 50 tonne earth-removal excavators and dozers and this machinery will be kept on-site during the construction phase. Operation of the plant machinery and equipment during the construction phase will generate particulate and gaseous emissions from the exhausts of the diesel engines.

The short-term movement of peat during the excavation of the new cells and construction of the boundary berms has a low potential for generating significant quantities of dust. This is due to the nature of the material which has a relatively high moisture content and a large range of particle sizes so it will not be prone to dust-blow during strong winds. Since the cells will be lined, there will be negligible emissions of dust from the excavated cell prior to commencement of filling. On completion of the main construction phase the slopes of the boundary berms will be compacted and landscaped to reduce the potential for dust emissions from the slopes.

It is predicted that emissions of dust and PM_{10} during the construction phase will have a slight to moderate impact near to the areas of excavation and berm locations. However, beyond the site boundary these impacts on air quality are predicted to be slight or imperceptible with the implementation of the mitigation measures outlined in

Section 6.2. No adverse impact on the environment or community health is predicted as a result of airborne emissions during the construction phase.

6.2 Mitigation Measures

- Control of dust emissions from the surface of temporary haul roads used by machinery preparing the landfill extension area should be carried out with a mobile water sprayer during dry weather conditions.

- All construction vehicles will use the existing site entrance.

- Construction machinery will be kept on-site.

7.0 RESIDUAL IMPACTS

The mitigation measures that are proposed for the extension of the landfill will substantially reduce the potential emissions of odours and dust. Daily cover of the deposited waste material will significantly reduce the quantity of malodours being released from the surface of the active cells. The installation of a gas collection network, with flaring or burning the gas in a gas to energy utilisation plant will reduce emissions of landfill gas from the whole site. . Due to the nature of the activity, it is possible odorous emissions from the operational landfill will occasionally be detected in the area, with a slight to moderate short-term impact depending on weather conditions. However, with the continuing improvements being carried out and regular inspections for odours at the boundary as required under the conditions in the Waste Licence, it is predicted that impacts of malodours will continue to decline.

The dust control measures, such as a wheel-wash, construction of paved internal haul roads and spraying road surfaces with water during dry weather conditions should effectively control dust emissions from the landfilling and construction activities at Gortadroma. With these measures in place, the impact of dust emissions will be slight with no significant impact beyond the landfill boundary.