APPENDIX 7A

AIR DISPERSION MODELLING REPORT

Air Dispersion Modelling Report

Engineered Landfill

Blessington, Co Wicklow

June 2004

Produced for
Roadstone Dublin

Prepared by
James Stokes
Environmental Assistant

Knights House
2 Parade
Sutton Coldfield
West Midlands
B72 1PH

T 0121 355 8949
F 0121 355 8901
E james.stokes@mouchelparkman.com

Document Control Sheet

Project Title Blessington, Co Wicklow

Report Title Air Dispersion Modelling Report – Engineered Landfill

Revision 4000043/OR/5

Status B – Amended With Client Comment

Control Date June 2004

Record of Issue

Issue	Status	Author	Date	Check	Date	Authorised	Date
A		J Stokes	04/04	J Andrews	04/04	Dr C Chappell	04/04
B		J Stokes	05/04	A Jeffcoat	05/04	Dr C Chappell	05/04

Distribution

Organisation	Contact	Copies
John Barnett Associates	Derek Luby	1

Contents

1 Executive Summary

Current Status	The site is located in the county of Wicklow in Ireland and is owned by Roadstone Dublin Limited. The site area is approximately 276 hectares.
Landfill Source	Three unauthorised landfill sites known as Areas 1, 4 and 6, comprising an estimated 50,000 tonnes of domestic, commercial and industrial (DCI) Waste.
Landfill Characteristics	190 x 85m (16,150m^2 area) to be capped with a 5mm geosynthetic clay liner overlying a 1mm LLDPE Geomembrane, overlying a 5mm geosynthetic clay liner, overlying a 1m thick clay liner.
Model Parameters	Singe point emission of vent stack of 3m length and 0.1m diameter. Three potential receptors modelled: 1. Darkers Lane 450m north east from source 2. Residential housing 600m south east from source 3. Site boundary 20m east from source A wind rose with dominant flow direction from the south west was input into the model.
Model Results and Summary	Insignificant risk to human health at all receptors is likely from methane and carbon dioxide. Insignificant risk to human health or potential nuisance at all receptors is likely from odorous trace gas. Monthly gas monitoring is recommended during the operational phase of the landfill for safety of operators, further information for any remodelling and assessment of the impact of the works on air quality.

2 Introduction

Over the last few years there has been an increased detection of large scale unauthorised tipping of waste in the county of Wicklow in Ireland. Investigations at the Blessington landholding of Roadstone Dublin Limited (RDL) in early 2003 revealed that approximately 50,000 tonnes of domestic, commercial, and industrial (DCI) waste had been infilled at three unauthorised landfill sites over the last 10 years, together with a similar amount of construction and demolition (C&D) waste. The three unauthorised landfill sites are illustrated as Areas 1, 4 and 6 on the figure reproduced within Appendix A.

Mouchel Parkman has undertaken an environmental risk assessment of the threats to drinking water and groundwater posed by these unauthorised landfills and also reviewed the risks from landfill gas to a recently constructed housing development (Mouchel Parkman, August 2003).

Air dispersion modelling was conducted to predict down-gradient methane and carbon dioxide concentrations as well as potential odour issues that may result from the passive venting of landfill gases from the proposed non-hazardous engineered landfill on Roadstone Dublin's landholding at Blessington.

2.1 Previous Studies

The Mouchel Parkman Risk Assessment, Report 4000043/OR/03, prepared in consultation with the Environmental Protection Agency, concluded that remediation works of the unauthorised landfills was required due to the risk of landfill gas (recorded within Area 6) to nearby housing under construction. After considering the remediation options in terms of cost, environmental benefits, implementation and public impact, it was decided that all of the DCI waste would be transferred from each of the three affected areas to a proposed engineered landfill to be constructed within the Blessington site (see Appendix A).

It has been calculated that this waste will total approximately 55,000 tonnes of DCI waste. It has been assumed that up to a further 10,000 tonnes of inert C&D waste will also be placed in the landfill during deposition, with the balance of material deposited in the landfill comprising soils beneath and around the buried waste.

The proposed engineered landfill is located approximately 450m from the nearest housing development. These properties located at Darkers Lane are outlined on the figure provided (Appendix A).

2.2 Model Description

The GasSim model version 1.03 (supplied by Golder Associates) was selected for this assessment as it enables the combined contribution of vented gases and those released through the landfill surface cap to be considered. This model assumes that the landfill is a simple point source of emission, with atmospheric dispersion off-site simulated by a Gaussian plume deterministic model.

GasSim is a probabilistic model that uses the Monte Carlo simulation technique to select randomly from a pre-defined range of possible input values (probability density functions – PDF) to create parameters for use in the model calculations. Repeating the process many times gives a range of output values, the distribution of which reflects the uncertainty inherent in the input values. This enables the likelihood of the estimated output levels being achieved to be ascertained.

2.3 Model Assumptions

In modelling the landfill, it was necessary to make various assumptions about the discharge conditions that would then be incorporated into the future engineering designs. The model also required information to be input on the landfill design itself, including the source material composition, deposition rates and hydrogeological parameters. These parameters and their justifications are included in the following sections and are summarised in Appendix B. In general, parameters were chosen to provide a conservative estimation of risk, which is tending to a 'worst case' situation that could apply.

3 Pollutants and Air Quality Guidance

The following table gives a list of pollutants that were modelled with the relevant environmental assessment levels (EAL's) and odour thresholds. The trace gases were chosen as they form the odorous components of landfill gas:

Gas Modelled	Long Term EAL taken from EA's H1 Guidance (mg/m3)	Odour Threshold (mg/m3) - GasSim Default
Carbon disulphide	0.064	0.7
Diethyl disulphide	Not Applicable	0.0003
Dimethyl sulphide	Not Applicable	0.0037
Ethanethiol (ethyl mercaptan)	0.013	0.00046
Hydrogen sulphide	0.14	0.0001
Limonene	Not Applicable	0.02
Methanethiol (methyl mercaptan)	0.01	0.0002
Propanethiol	Not Applicable	0.00014
Toluene	1.91	0.7
Xylene	4.41	0.54

According to H1 Guidance issued by the EA*, air emissions are considered to be insignificant if the maximum process contribution (long term) is less than or equal to 1% of the long term EAL as provided above.

When considering methane (CH_4) and carbon dioxide (CO_2), the Irish EPA guidelines of 1% and 0.5% respectively were considered (Irish Department of Environmental Standards for Building Construction).

* UK Environment Agency – Horizontal Guidance Note IPPC H1 "Environmental Assessment and Appraisal of BAT"

4 Landfill Source

For the purposes of modelling we have assumed that source material from Areas 1,4 and 6 will be deposited in the engineered landfill between 2004 and 2005, reaching a total of 65,000 tonnes. This was input to the model as a uniform range of between 19,500 to 23,800 tonnes for 2004, increasing to between 39,000 to 47,700 tonnes in 2005. A zero waste amount was then input to the model for the years between 2006 and 2022.

During the period of waste deposition, it was assumed that 75% of the waste was covered by some form of cap. From the time of completion, in 2005, it was then assumed that all the waste was covered with a capping layer.

For the purposes of the model it was assumed that the 55,000 tonnes of DCI waste was split between approximately equal amounts of commercial, industrial and domestic waste. GasSim contains default waste streams for commonly deposited waste materials filled between 1980 and 2010, from HELGA (Gregory et al., 1999), this is enclosed as Appendix D. The composition of each type of waste was determined for the model using the model default values for 1980's to 2010 waste streams. This was input as a uniform range 21% to 37.4% of total waste input to the proposed landfill for each of the three waste types.

Up to a further 10,000 tonnes of residual C&D waste was also assumed within the model and given as a uniform range between 7.7% and 15.4% of total waste input to the proposed landfill.

5 Landfill Characteristics

The landfill area was input as 190m x 85m giving a total area of 16,150 m^2, which has been assessed as being the potential area of active waste deposited. Biological methane oxidation was limited to 10%, this being the proportion suggested by DEFRA* policy.

It is intended that the waste material is to be capped with a 5mm thick Geosynthetic Clay Liner overlying a 1mm thick Linear Low Density Polyethylene (LLDPE) Geomembrane. This was included in the model as a 0.005m thick layer with a hydraulic conductivity of 5E-11m/sec, with a second layer of 0.001m thickness with a hydraulic conductivity of 4.3E-19m/sec. Whilst this may reduce the degree of methane release from the surface it should enhance the content of gases released passively through the proposed landfill gas management system.

It is also proposed that the base of the landfill is to be lined with a 2mm thick high density polythene (HDPE) Geomembrane, overlying a 5mm thick Geosynthetic Clay Liner, overlying a 1m thick clay liner. This was included in the model as a 0.002m thick layer with a hydraulic conductivity of 4.3E-19m/sec, with a second layer of 0.005m with a hydraulic conductivity of 5E-11m/sec, and a third layer of 1m with a hydraulic conductivity of 1E-9m/sec.

As the presence of recirculated leachate is likely within the engineered landfill, a 'wet' scenario was selected for the model using the GasSim default.

Previous hydrogeological analysis provided a representative value for the hydraulic conductivity of 0.865m/day (or 0.00001m/sec).

Default values for moderate cellulose decay rates were included in the model set up. It was also assumed that any vented gases would comprise 66% methane in the first instance. 66% methane is the likely maximum concentration of methane in any landfill gas generation *(Department of Environment – Waste Management Paper 27)*

The value for infiltration, uniform PDF of 10 to 15 mm/year *(provided by JBA)*, corresponds to 1-1.5% of annual rainfall recorded locally and was decided using professional judgement based on the cap design of the landfill.

---

* DEFRA – UK – Department for Environment Food and Rural Affairs

6 Emission Parameters - Gas Plant

The GasSim programme has been adapted to model a single point emission. To achieve this, the air / fuel ratio was lowered to 0.01 and ambient air temperature (20^{0}C) was assumed, thereby removing aspects of bleeding and heating that would be associated with an engine. Furthermore there was assumed to be no down time to represent constant passive venting. Similarly zero methane destruction efficiency was assumed and no operational flares were modelled. The assumed vent stack dimensions were a diameter of 0.1 m and height of 3 m.

The first model runs were based on emissions occurring from 2004 onwards. The proportion of methane and carbon dioxide in the exhaust streams were input as 66% and 16.8%, respectively, these concentrations having been previously recorded in the landfill *(area 6)*. Predicted levels of generated CH_4 and CO_2 are provided within Appendix E. Production of landfill gas peaks in 2006, with an estimated 87m^3/hr of CH_4 and 44m^3/hr of CO_2 being generated. With the simulation of a single vent point, generated levels of landfill gas decline to approximately half peak levels over three years. However, generated levels are then shown to gradually decline over the next fifteen years with approximately one eighth of peak levels still being generated in 2024.

Landfill gas generation is expected to occur for approximately thirty years after deposition *(Department of Environment – Waste Management Paper 27)*. Therefore predicted levels of landfill gas are expected to continue to decrease after 2024, for approximately 10 more years before the generation of landfill gas ceases. Management measures, such as gas flaring, could potentially be incorporated to reduce the generated levels of methane gas over time.

The model shows that the predicted CH_4 and CO_2 discharge rate between 2004 and 2024 were 6.6m^3/hour and 3.3m^3/hour, respectively, for a single vent point with the above dimensions. Therefore, at least fourteen separate vents with the above dimensions would be required for dispersion of generated landfill gas at peak levels. The vent output graphs are also attached in Appendix E.

Default concentrations in the landfill gas were assumed for the model and these were compared with trace gas concentrations recorded during monitoring. Particular attention was given to the standard odour suite, which includes a range of sulphur containing hydrocarbons (known as thiols or mercaptans), gaseous sulphides, xylene, toluene and limonene. Trace gas default inputs for odorous components of landfill gas are shown in the table (Appendix F), these default trace gas concentrations were derived from performing statistical analysis on the data gathered by a number of authors (AERC draft database, 2001; Derwent et al., 1996; and Stoddart et al., 1999). Concentrations recorded during in-situ monitoring that exceeded the relevant default values were also input for re-runs of the model, with the outcome discussed in Section 7.

7 Atmospheric Dispersion Parameters

Dispersion of methane and carbon dioxide to the following receptors was modelled with each receptor assumed to be located down gradient from the venting source to provide the most conservative modelled scenario. The location of the three receptors are shown on the drawing within Appendix A. Each receptor was considered to be at the same elevation as the vent stack, although further analysis (not reported) showed that variation on the height did not influence the results.

Receptor	Distance from Source (m)	Direction from Source
1. Darkers Lane (isolated rural housing)	450	NE
2. Residential Housing (near Area 6)	600	SE
3. Site Boundary	20	E

For air dispersion, a wind rose with dominant flow direction from the southwest was input to the model, *as provided by JBA.* The values input are summarised in the following table:

Wind Direction	Frequency
30	0.03
60	0.06
90	0.10
120	0.05
150	0.04
180	0.07
210	0.17
240	0.25
270	0.13
300	0.04
330	0.03
0	0.03

It was assumed that each receptor was down gradient of the predominant wind direction, thus providing a conservative assessment.

Default values of Pasquill data were assumed. These simulate aspects of atmospheric stability, wind speeds and mixing depths for gases.

8 Model Results

8.1 Dispersion

Using the GasSim model the predicted atmospheric dispersion of landfill gas to each of the three receptors was modelled as follows.

8.1.1 Bulk Landfill Gas

The predicted methane (CH_4) and carbon dioxide (CO_2) concentrations at the receptors are summarised in the following table. These cover the period from 2005 onwards.

Year	CO_2 at Receptor 1 (mg/m^3)	CH_4 at Receptor 1 (mg/m^3)	CO_2 at Receptor 2 (mg/m^3)	CH_4 at Receptor 2 (mg/m^3)	CO_2 at Receptor 3 (mg/m^3)	CH_4 at Receptor 3 (mg/m^3)
2005	0.0096	0.0054	0.0068	0.0049	0.43	0.23
2006	0.028	0.016	0.017	0.013	1.32	0.72
2007	0.021	0.011	0.013	0.0094	0.95	0.52
2008	0.016	0.0089	0.01	0.0075	0.73	0.40
2009	0.013	0.0074	0.0087	0.0064	0.6	0.36
2010	0.011	0.0063	0.0076	0.0056	0.51	0.28
2011	0.0098	0.0055	0.0068	0.005	0.44	0.24
2012	0.0087	0.0049	0.0062	0.0046	0.39	0.21
2013	0.0078	0.0044	0.0057	0.0042	0.34	0.19
2014	0.0069	0.004	0.0052	0.0038	0.30	0.17
2015	0.0062	0.0036	0.0048	0.0035	0.27	0.15
2016	0.0055	0.0032	0.0044	0.0033	0.24	0.13

Receptor 1 – Darkers Lane

The model results predict a maximum methane concentration of 0.016mg/m^3 at receptor 1, located 450m down gradient from the vent stack, with carbon dioxide reaching a maximum of 0.028mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately twelve million times greater than the maximum predicted. Asphyxiation from carbon dioxide can occur at concentrations in excess of 0.5% v/v (9,200 mg/m^3), a value approximately three hundred thousand times greater than the maximum recorded.

Receptor 2 – Residential Housing near Area 6

The model results predict a maximum methane concentration of 0.013mg/m^3 at receptor 2, located 600m down gradient from the vent stack, with carbon dioxide reaching a maximum of 0.017mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately twenty million times greater than the maximum recorded. Asphyxiation from carbon dioxide can occur at concentrations in excess of

0.5% v/v (9,200 mg/m^3), a value approximately five hundred thousand times greater than the maximum recorded.

Therefore, based on the model predictions, the venting of methane and carbon dioxide from the engineered landfill should not pose a risk to public health of occupants in the nearby residential areas. The lower explosive limit for methane is 5% v/v (33333mg/m^3). This is approximately two million times greater than the maximum predicted methane concentration (0.016mg/m^3 at receptor 1) and hence there is likely to be no significant risk for any explosion at either receptor.

Receptor 3 – Site Boundary

When considering the nearest site boundary, the model predicts a maximum methane concentration of 0.72mg/m^3 at receptor 3, located 20m down gradient from the vent stack, with carbon dioxide reaching a maximum of 1.32mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately two hundred and fifty thousand times greater than the maximum recorded. Asphyxiation from carbon dioxide can occur at concentrations in excess of 0.5% v/v (9,200 mg/m^3), a value approximately seven thousand times greater than the maximum recorded. The lower explosive limit for methane is 5% v/v (33333mg/m^3). This is approximately five thousand times greater than predicted methane concentration and hence there is likely to be no significant risk for any explosion at the site boundary.

8.1.2 *Odorous Emissions*

The emission of landfill gas was also considered in terms of odour thresholds being exceeded at each receptor. The predicted concentrations of trace compounds considered to represent the most odorous emissions from landfills are provided in the tables below.

Receptor 1 – Darkers Lane

	Predicted Trace Gas Concentration (mg/m³) at Receptor 1									
	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene
2005	1.4e-7	9.8e-11	7.6e-7	2.2e-7	1.5e-5	2.6e-6	4.9e-7	9.2e-8	6.9e-6	2.3e-5
2006	4.3e-7	9.5e-11	2.3e-6	8.0e-7	4.1e-5	7.6e-6	1.4e-6	2.6e-7	2.2e-5	6.6e-5
2007	2.5e-7	8.1e-11	1.5e-6	4.8e-7	2.5e-5	4.5e-6	7.6e-7	1.5e-7	1.1e-5	3.8e-5
2008	1.6e-7	7.0e-11	9.9e-7	3.1e-7	1.4e-5	2.9e-6	5.0e-7	9.9e-8	8.0e-6	2.5e-5
2010	7.7e-8	5.1e-11	5.0e-7	1.5e-7	7.1e-6	1.4e-6	2.4e-7	4.6e-8	4.5e-6	1.2e-5
2012	4.1e-8	3.7e-11	2.2e-7	8.5e-8	4.1e-6	7.5e-7	1.3e-7	2.8e-8	2.4e-6	5.6e-6
2014	2.4e-8	2.7e-11	1.0e-7	4.9e-8	2.0e-6	4.1e-7	6.3e-8	1.7e-8	1.4e-6	3.1e-6
2016	1.4e-8	2.0e-11	4.7e-8	2.8e-8	1.2e-6	2.1e-7	3.4e-8	1.0e-8	7.5e-7	1.7e-6
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54
1% of EAL	6.4e-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2

*** No Standard Available**

In all cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix A) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m³), limonene (2.5mg/m³), toluene (1.1mg/m³) and xylene (0.009mg/m³). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. Again in all cases the predicted trace gases were predicted below the associated thresholds at receptor 1. Therefore odorous trace gases should pose no significant risk to human health and cause no nuisance.

Receptor 2 – Residential Housing near Area 6

Predicted Trace Gas Concentrations (mg/m³) at Receptor 2	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene
2005	1.3e-7	6.3e-11	6.7e-7	2e-7	1.3e-5	2.3e-6	4.3e-7	7.9e-8	6.2e-6	2e-5
2006	3.2e-7	6.1e-11	1.7e-6	6e-7	3e-5	5.5e-6	1e-6	1.9e-7	1.6e-5	4.8e-5
2007	1.9e-7	5.3e-11	1.1e-6	3.8e-7	1.9e-5	3.4e-6	5.8e-7	1.2e-7	8.5e-6	2.9e-5
2008	1.3e-7	4.5e-11	7.8e-7	2.5e-7	1.1e-5	2.2e-6	3.9e-7	7.7e-8	6.2e-6	1.9e-5
2010	6.6e-8	3.3e-11	4.1e-7	1.3e-7	6.1e-6	1.2e-6	2e-7	3.9e-8	3.7e-6	1e-5
2012	3.7e-8	2.4e-11	1.9e-7	8e-8	3.8e-6	6.8e-7	1.1e-7	2.4e-8	2.2e-6	5.1e-6
2014	2.3e-8	1.8e-11	9.5e-8	4.9e-8	1.9e-6	3.9e-7	5.9e-8	1.6e-8	1.3e-6	3.1e-6
2016	1.4e-8	1.3e-11	5e-8	3.1e-8	1.2e-6	2.3e-7	3.7e-8	1e-8	7.8e-7	1.1e-6
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54
1% of EAL	6.4E-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2

*** No Standard Available**

In all cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix A) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m³), limonene (2.5mg/m³), toluene (1.1mg/m³) and xylene (0.009mg/m³). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. Again in all cases the predicted trace gases were found to be below the associated thresholds at receptor 2. Therefore odorous trace gases should pose no significant risk to human health and cause no nuisance.

Receptor 3 – Site Boundary

Predicted Trace Gas Concentrations (mg/m³) at Receptor 3	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene
2005	6.6e-6	4.9e-10	3.6e-5	1.0e-5	7.2e-4	1.2e-4	2.3e-5	4.4e-6	3.3e-4	1.1e-3
2006	2.0e-5	4.7e-10	1.1e-4	3.8e-5	1.9e-3	3.6e-4	6.6e-5	1.2e-5	1.0e-3	3.1e-3
2007	1.2e-5	4.0e-10	6.9e-5	2.3e-5	1.2e-3	2.1e-4	3.6e-5	7.3e-6	5.4e-4	1.8e-3
2008	7.7e-6	3.4e-10	4.7e-5	1.5e-5	6.5e-4	1.4e-4	2.3e-5	4.7e-6	3.8e-4	1.2e-3
2010	3.6e-6	2.5e-10	2.4e-5	7.3e-6	3.6e-4	6.6e-5	1.1e-5	2.2e-6	2.1e-4	5.8e-4
2012	1.9e-6	1.8e-10	1.1e-5	4.0e-6	1.9e-4	3.5e-5	5.9e-6	1.3e-6	1.2e-4	2.6e-4
2014	1.1e-6	1.4e-10	4.8e-6	2.3e-6	9.6e-5	1.9e-5	3.0e-6	8.1e-7	6.5e-5	1.5e-4
2016	6.6e-7	1.0e-10	2.2e-6	1.3e-6	5.6e-5	9.9e-6	1.6e-6	4.7e-7	3.6e-5	8.0e-5
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54
1% of EAL	6.4E-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2

*** No Standard Available**

The shaded cells show predicted levels that exceed associated thresholds. The model predicts significant levels of hydrogen sulphide (greater than the odour threshold) between the years 2005 and 2012 at the nearest site boundary.

In all other cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix A) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m^3), limonene (2.5mg/m^3), toluene (1.1mg/m^3) and xylene (0.009mg/m^3). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. No further predicted trace gases were found to be above the associated thresholds.

To provide a more accurate simulation for predicted levels of hydrogen sulphide, the model was again re-run using the most recent monitoring results as outlined above. For this odorous gas levels were found to be less than detection at all locations. Therefore the detection level was input into the model to replace the GasSim default values, i.e. 1ppb for hydrogen sulphide (0.00142mg/m^3). When modelling the on-site recorded level, predicted concentrations at the nearest site boundary were found to be well below the associated thresholds.

8.2 Lateral Gas Migration

Lateral gas migration was also modelled using GasSim. The model simulates lateral migration using a one dimensional flow model, which is emitted uniformly from all sides of the landfill. It uses an advection and dispersion equation to simulate the migration of gas through the landfill liner. Using the model the predicted lateral migration of landfill gas in relation to the nearest site boundary (to the east of the landfill) was investigated.

8.2.1 Bulk Landfill Gas

Concentrations of methane and carbon dioxide just outside the landfill boundary were calculated to be 383,000mg/m3 (52%) and 501,000mg/m^3 (25%) respectively. However, at a distance of 12m from the proposed landfill methane concentrations become zero, and at a distance of 11m away carbon dioxide concentrations become zero. The nearest site boundary is approximately 20m from the edge of the proposed landfill position, and therefore there should be no significant risk to any potential future development from lateral migration.

8.2.2 Odorous Emissions

When considering odorous trace gases, the model predicted that for all species the concentration would be zero beyond 8m from the landfill boundary. Again there should be no significant risk to any potential future development from the lateral migration of odorous trace gases.

The output graphs showing the lateral migration of landfill gas are provided within Appendix G.

Irrespective of the above findings, the installation of the proposed venting measures should intercept any lateral migration of gas and disperse it into the atmosphere.

9 Summary of Air Dispersion Modelling

Risk assessment undertaken using the GasSim model indicates that the risks posed to housing development from the predicted generation of methane and carbon dioxide in the proposed engineered landfill are likely to be insignificant. Modelled receptor concentrations of these gases are significantly below accepted limits of explosion and asphyxiation, and therefore the risk to human health at the receptors is likely to be insignificant. The landfill engineering design is therefore regarded to provide a large safety margin in this respect.

Modelled concentrations of odorous trace gases generated by the landfill are unlikely to pose a significant problem for the residents of the nearby housing developments when considering public health and potential nuisance. However when considering odorous trace gas modelled at the nearest site boundary, significant volumes of hydrogen sulphide are predicted (i.e. greater than threshold levels) when using GasSim default source levels.

When the model was re-run using actual recorded values, all of the odorous trace gases were found to be well below threshold levels at the nearest site boundary. As this scenario provides a more accurate picture of site conditions, it is anticipated that there should be no significant risk to public health or public nuisance to any potential future development at the site boundary from odorous landfill gas.

It is recommended that gas monitoring is carried out monthly during the operational phase of the landfill to provide a safety margin during operations and to provide information for any further GasSim modelling work, if required. All model results assume passive venting of gas, however, it is understood that flares will be incorporated into the landfill design for the management of landfill gas. Therefore, should monitoring indicate a potential for flaring, the landfill flares can then be operated.

10 Appendices

APPENDIX A

SITE INFRASTRUCTURE LAYOUT

A	First Issue	GTS 06/04	AJ 06/04	PRR 06/04
Version	Amendment	Originated by and date	Checked by and date	Approved by and date

mouchelparkman

Client	CRH
Project	Blessington, Co. Wicklow
Purpose	Information
Drawing Title	SITE INFRASTRUCTURE LAYOUT
Draft	●
Issue	
Scale (at A3 size)	1 : 5000
Issuing Office	Sutton Coldfield
Telephone	0121 355 8949
Drawing number	4000043/A/38
Version	A

roadstone
ROADSTONE DUBLIN LTD.
FORTUNESTOWN
TALLAGHT
DUBLIN 24

JBA SLR
JOHN BARNETT & ASSOCIATES
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14

Roadstone Landholding Boundary
Waste Licence Application Area

APPENDIX B

GasSim INPUT PARAMETERS

APPENDIX B

Table 1: GasSim input parameters			
Parameter	**Value**	**Units**	**Justification**
Infiltration	Uniform (10,15)	mm/year	Professional Judgement
Waste Input	65,000	tonnes	As confirmed with JBA (03/04/04)
% Waste in place capped	Always 75 then 100	%	Assumption
Waste Moisture Content			
Wetness	Wet		Professional Judgement
Waste Density	Uniform (0.6,1.0)	t/m3	Professional Judgement (Landsim Report)
Leachate Head	1	m	Assumed as standard required in landfill
Hydraulic Conductivity	0.00001	m/s	From Alan's model
Waste Breakdown			
Domestic	Uniform (21,37.4)	%	Approx 28.2% of 65,000 tonnes
Commercial	Uniform (21,37.4)	%	Approx 28.2% of 65,000 tonnes
Industrial	Uniform (21,37.4)	%	Approx 28.2% of 65,000 tonnes
Inert	Uniform (7.7,15.4)	%	Approx 15.4% of 65,000 tonnes
Proportion to CO2	15.1	%	Based on gas monitoring visits
Proportion to CH4	30.3	%	Based on gas monitoring visits
Waste Composition &			Default values for 1980s to 2010 waste streams
Cellulose Decay Rates			Default values for 1980s to 2010 waste streams
Landfill Characteristics			
Length N/S	190	m	2 cells x 95m (LandSim report)
Length E/W	85	m	LandSim report
Area	16150	m2	
Cap			
Layer 1 thickness	0.005	m	Info from JBA fax received 07/04/04
Layer 1 Hydraulic Conductivity	5E-11	m/s	Info from JBA fax received 07/04/04
Layer 2 thickness	0.001	m	Info from JBA fax received 07/04/04
Layer 2 Hydraulic Conductivity	4.3E-19	m/s	Info from JBA fax received 07/04/04
Liner			
Layer 1 thickness	1	m	Info from JBA fax received 07/04/04
Layer 1 Hydraulic Conductivity	0.000000001	m/s	Info from JBA fax received 07/04/04
Layer 2 thickness	0.005	m	Info from JBA fax received 07/04/04
Layer 2 Hydraulic Conductivity	5E-11	m/s	Info from JBA fax received 07/04/04
Layer 3 thickness	0.002	m	Info from JBA fax received 07/04/04
Layer 3 Hydraulic Conductivity	4.3E-19	m/s	Info from JBA fax received 07/04/04
Biological Methane Oxidation	10	%	Suggested by DEFRA (GasSim Manual)

APPENDIX C

GasSim PROJECT DETAILS

Project Details

Project name: Engineered Landfill
Client: Roadstone Dublin
Model: G:\Inter Divisional\4000043 CRH Blessington\GasSim\Engineered Landfill.gss
Model Date: 16/04/2004 16:14:53
Comments:
Initial Model
Start Year : 2004
Simulation Period : 20 years
Operation Period : 19 years
Iterations: 100

Infiltration

UNIFORM(10.0, 15.0)

Justification:
JBA Professional Judgement

Waste Input

Year	Amount Deposited [t]	Composition	% Waste In Place Capped
2004	UNIFORM(1.95E+04, 2.38E+04)	1980's - 2010 waste streams	SINGLE(75)
2005	UNIFORM(3.90E+04, 4.77E+04)	1980's - 2010 waste streams	SINGLE(100)
2006	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2007	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2008	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2009	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2010	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2011	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2012	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2013	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2014	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2015	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2016	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2017	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2018	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2019	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2020	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2021	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)
2022	SINGLE(0)	1980's - 2010 waste streams	SINGLE(100)

Justification:
Approximately 65000 tonnes over 18 months starting 2004 as confirmed with JBA (03/04/04)

100% Cap at end of operational period

Justification:
Assumed to be 75% until completion agreed with JBA

Waste Moisture Content

Wet
Justification:
Moisture content inputs based on professional judgement

Waste Density [t/m3]: UNIFORM(0.6, 1.0)
Professional judgement (Landsim Report)

Leachate Head [m]: SINGLE(1)
Assumed standard in landfill

Hydraulic Conductivity [m/s]: SINGLE(0.00001)
From previous hydrogeological investigation

Waste Breakdown

2004	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2005	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2006	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2007	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2008	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2009	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2010	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2011	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2012	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2013	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)

2014	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2015	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2016	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2017	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2018	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2019	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2020	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2021	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)
2022	
Domestic	UNIFORM(21.0, 37.4)
Commercial	UNIFORM(21.0, 37.4)
Industrial	UNIFORM(21.0, 37.4)
Inert	UNIFORM(7.7, 15.4)

Justification:
Split between CDI with up to 10,000 tonnes C&D (Inert)

Proportion to Carbon Dioxide [%] SINGLE(15.1)
Justification:
Based on previous gas monitoring visits

Proportion to Methane [%] SINGLE(30.3)
Justification:
Based on previous gas monitoring visits

Cellulose Decay Rates

	Dry	Average	Wet
Slow	SINGLE(0.013)	SINGLE(0.046)	SINGLE(0.076)
Moderate	SINGLE(0.046)	SINGLE(0.076)	SINGLE(0.116)
Fast	SINGLE(0.076)	SINGLE(0.116)	SINGLE(0.694)

Justification:
Default Value

Trace Gases

Source Gases	**Concentration [mg/m3]**
Carbon disulphide	LOGTRIANGULAR(0.01, 0.1, 11.0)
Diethyl disulphide	LOGTRIANGULAR(1.00E-03, 2.00E-02, 2.60E+00)
Dimethyl disulphide	LOGTRIANGULAR(1.00E-03, 2.00E-02, 4.00E+01)
Dimethyl sulphide	LOGTRIANGULAR(1.00E-03, 1.00E-02, 6.00E+01)
Ethanethiol (ethyl mercaptan)	LOGTRIANGULAR(0.01, 0.05, 41.9)
Hydrogen sulphide	LOGTRIANGULAR(5.70E-04, 2.40E+00, 5.57E+03)
Limonene	LOGTRIANGULAR(1.00E-03, 1.00E-01, 2.40E+02)
Methanethiol (methyl mercaptan)	LOGTRIANGULAR(0.005, 0.01, 87.0)
Odour Units (Predicted)	TRIANGULAR(6.00E+04, 1.25E+05, 2.50E+05)
Propanethiol	LOGTRIANGULAR(0.2, 0.2, 2.1)
Sulphide, total simulations with H2S	LOGTRIANGULAR(1.00E-03, 2.40E+00, 5.58E+03)
Sulphide, total simulations without H2S	LOGTRIANGULAR(5.00E-04, 8.00E-03, 3.50E+00)
Toluene	LOGTRIANGULAR(0.01, 0.1, 1250.0)
Xylene (all isomers)	LOGTRIANGULAR(1.00E-03, 1.00E-03, 6.18E+04)

Justification:
Default Values for odour suite

Trace Gas Half-life (years) NORMAL(4.11, 1.56)
Justification:
Default Value

Landfill Characteristics

Landfill Geometry

Length N/S [m] SINGLE(190)
Length E/W [m] SINGLE(85)
Area [m2] 16150

Justification:
Taken from LandSim Report

Engineered Controls

Cap
Composite
First Layer:
Thickness [m] SINGLE(0.005)
Hydraulic conductivity [m/s] SINGLE(0.00000000005)
Second Layer:
Thickness [m] SINGLE(0.001)
Hydraulic Conductivity [m/s] SINGLE(4.3E-19)

Justification:
Thickness: Information provided by JBA
Conductivity: Information provided by JBA

Liner
Double Composite
First Layer:

Thickness [m]	SINGLE(1)
Hydraulic Conductivity [m/s]	SINGLE(0.000000001)

Second Layer:

Thickness [m]	SINGLE(0.005)
Hydraulic Conductivity [m/s]	SINGLE(0.00000000005)

Third Layer:

Thickness [m]	SINGLE(0.002)
Hydraulic Conductivity [m/s]	SINGLE(4.3E-19)

Fourth Layer:

Thickness [m]	SINGLE(0)
Hydraulic Conductivity [m/s]	SINGLE(1)

Justification:
Thickness: Information provided by JBA
Conductivity: Information provided by JBA

Gas Plant

Engine 2005 to 2024 10 Downtime [%]: SINGLE(0)
Justification:
Modelled to simulate passive venting

Justification for Ordering:
Not Justified

	Air/Fuel ratio	Methane Destruction Efficiency [%]	Hydrogen Destruction Efficiency [%]
Engines	0.01	SINGLE(0)	SINGLE(0)

	Height [m]	Orifice Diameter [m]	Temperature [C]
Engines	3	0.1	20

Justification:
0 Modelled to simulate passive venting
0 Modelled to simulate passive venting

Collection Efficiency SINGLE(100)

Justification:
100% Modelled to simulate passive venting

Trace Gas Plant

Carbon disulphide

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Diethyl disulphide

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Dimethyl disulphide

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Dimethyl sulphide

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Ethanethiol (ethyl mercaptan)

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Hydrogen sulphide

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Limonene

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Methanethiol (methyl mercaptan)

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Odour Units (Predicted)

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Propanethiol

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Sulphide, total simulations with H2S

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Sulphide, total simulations without H2S

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Toluene

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Xylene (all isomers)

Engine:	non-combustion products	SINGLE(99)
Flare:	non-combustion products	SINGLE(99)

Atmospheric Dispersion

User Defined Meteorological Data

Wind Rose:

Heading:	0	30	60	90	120	150	180	210	240	270	30
Probability:	0.03	0.03	0.06	0.10	0.05	0.04	0.07	0.17	0.25	0.13	0.04

Pasquill Data:

Category:	A	B	C	D	E	F/G
Frequency [%]:	0.75	5.725	16.3	62.4	6.7	8.4
Wind Speed [m/s]:	1	2	5	5	3	1.5
Mixing Layer Depth [m]:	1300	900	850	800	400	100

Atmospheric Temperature [°C]: 20
Pressure [mbars]: 101.36
Atmospheric Density [g/m3]: 1293
Potential Density Gradient [K/m]: 0.009

Washout Coefficient [s-1]: 0.0001
Deposition Velocity [m/s]: 0.01

Terrain Type: Parkland/Open suburbia
Roughness Length [m]: 0.5
Effective Windspeed Coefficient: 0.3

JBA rose as provided

Odour

Compound: Toluene
Limit [mg/m3]: 1

Default Value

Lateral Migration

Bulk Gases
Air Diffusion Coefficients
Carbon Dioxide [cm2/s]: SINGLE(0.1613)
Methane [cm2/s]: SINGLE(0.2192)
Hydrogen [cm2/s]: SINGLE(0.00001)

Not Justified

Geosphere
Moisture Content [%]: SINGLE(10)
Porosity [%]: SINGLE(45)

Default pasquill values

Trace Gases

Gas	Air Diffusion Coefficient
Carbon disulphide	SINGLE(0.108)
Diethyl disulphide	#UNDEFINED?
Dimethyl disulphide	SINGLE(0.0898)
Dimethyl sulphide	SINGLE(0.0898)
Ethanethiol (ethyl mercaptan)	#UNDEFINED?
Hydrogen sulphide	SINGLE(0.1623)
Limonene	#UNDEFINED?
Methanethiol (methyl mercaptan)	#UNDEFINED?
Odour Units (Predicted)	#UNDEFINED?
Propanethiol	#UNDEFINED?
Sulphide, total simulations with H2S	#UNDEFINED?
Sulphide, total simulations without H2S	#UNDEFINED?
Toluene	SINGLE(0.087)
Xylene (all isomers)	SINGLE(0.0684)

Default Value

Global Impact

Bulk Gases
Global Warming Potential
Carbon Dioxide [t]: 1
Methane [t carbon dioxide]: 21
Hydrogen [t carbon dioxide]: 0

Default Value

Ozone Depletion Potential
Carbon Dioxide [t trichlorofluoromethane]: 0
Methane [t trichlorofluoromethane]: 0
Hydrogen [t trichlorofluoromethane]: 0

Default Value

Trace Gases

Gas	Global Warming Potential	Ozone Depletion Potential
Carbon disulphide	0	0
Diethyl disulphide	0	0
Dimethyl disulphide	0	0
Dimethyl sulphide	0	0
Ethanethiol (ethyl mercaptan)	0	0
Hydrogen sulphide	0	0
Limonene	0	0
Methanethiol (methyl mercaptan)	0	0
Odour Units (Predicted)	0	0
Propanethiol	0	0

Sulphide, total simulations with H2S	0	0
Sulphide, total simulations without H2S	0	0
Toluene	0	0
Xylene (all isomers)	0	0

Exposure

Scenario: Residential without Plant Uptake
Year: 2004
Distance from boundary [m]: 0
Direction: North East
Emissions to model: <None Selected>
Gas Viscosity [N.hr/m2]: 0.000000005
Henry's law constant:
Soil Type: Loam
Soil Organic Matter [%]: 5
Wind speed above ground surface in ambient mixing zone [cm/s]:12
Depth below ground to contaminated source zone [cm]:1

Building Characteristics

Area of walls in living space [m2]:	186
Area of windows [m2]:	20
Area of floor [m2]:	74.1
Height of Living space [m]:	5.4
Air exchange rate (total exchanges per hour)	1
Perimeter of building [m]:	34.4
Air pressure inside house [Pa]:	101321.5
Area of house walls in cellar [m2]:	6.88
Height of subfloor void [m]:	0.5
Air pressure inside subfloor void [Pa]:	101325
Temperature inside house [C]:	555
Floor resistance [NH/m3]:	27.8
Average height of all openings [m]:	2

Building Materials

Material	Total Porosity [cm3/cm3]	Air-filled porosity [cm3/cm3]	Thickness [m]
Hardcore	0.5	0.25	0.1
Blinding Sand	0.5	0.5	0.05
Concrete	0.068	0.034	0.1
Insulating layer (floors)	0.9	0.9	0.05
Brick (external walls)	0.5	0.25	0.1
Lightweight block (walls)	0.068	0.068	0.1
Insulating layer (walls)	0.9	0.9	0.055
Plasterboard (ceiling)	0.068	0.068	0.0125
Insulating layer (roof)	0.9	0.9	0.1
Screed (over beam/block floor)	0.068	0.068	0.05
Suspended timber floor	0.2	0.2	0.03

APPENDIX D

COMPOSITION OF 1980 TO 2010 WASTE STREAMS

Table 5.1a Composition of 1980's - 2010 Waste Streams

Degradable		Domestic	Civic Amenity	Commercial	Industrial	Inert	Liquid Inert	Sewage sludge	Composted organic material	Incinerator ash	Waste sorted at MRF	Recycling schemes	Chemical sludges	Industrial liquid waste	Water content (%)	Cellulose (%)	Hemi-cellulose (%)	Decomposition (%)
Paper/Card	Newspapers	11.38	10	10											30	48.5	9	35
	Magazines	4.87	11												30	42.3	9.4	46
	Other paper	10.07		50.1											30	87.4	8.4	98
	Liquid cartons	0.51													30	57.3	9.9	64
	Card packaging	3.84													30	57.3	9.9	64
	Other card	2.83													30	57.3	9.9	64
Textiles	Textiles	2.36	3.0												25	20	20	50
Miscellaneous combustible	Disposable nappies	4.35													20	25	25	50
	Other misc. combustibles	3.6													20	25	25	50
Putrescible	Garden waste	2.41	22												65	25.7	13	62
	Other putrescible	18.38		15											65	55.4	7.2	76
Fines	10mm fines	7.11	15												40	25	25	50
Sewage sludge	Sewage sludge							100							70	14	14	75
Composted organic material									100						30	Un 7.47, 9.69	Un 1.87, 2.40	57
Incinerator ash										100					30	Tri 0.5, 0.7,1.5	Tri 0.5, 0.7,1.5	57
Non-Degradable	Total	28.86	39	24.6	0	100	-	0	0	0					-	-	-	-

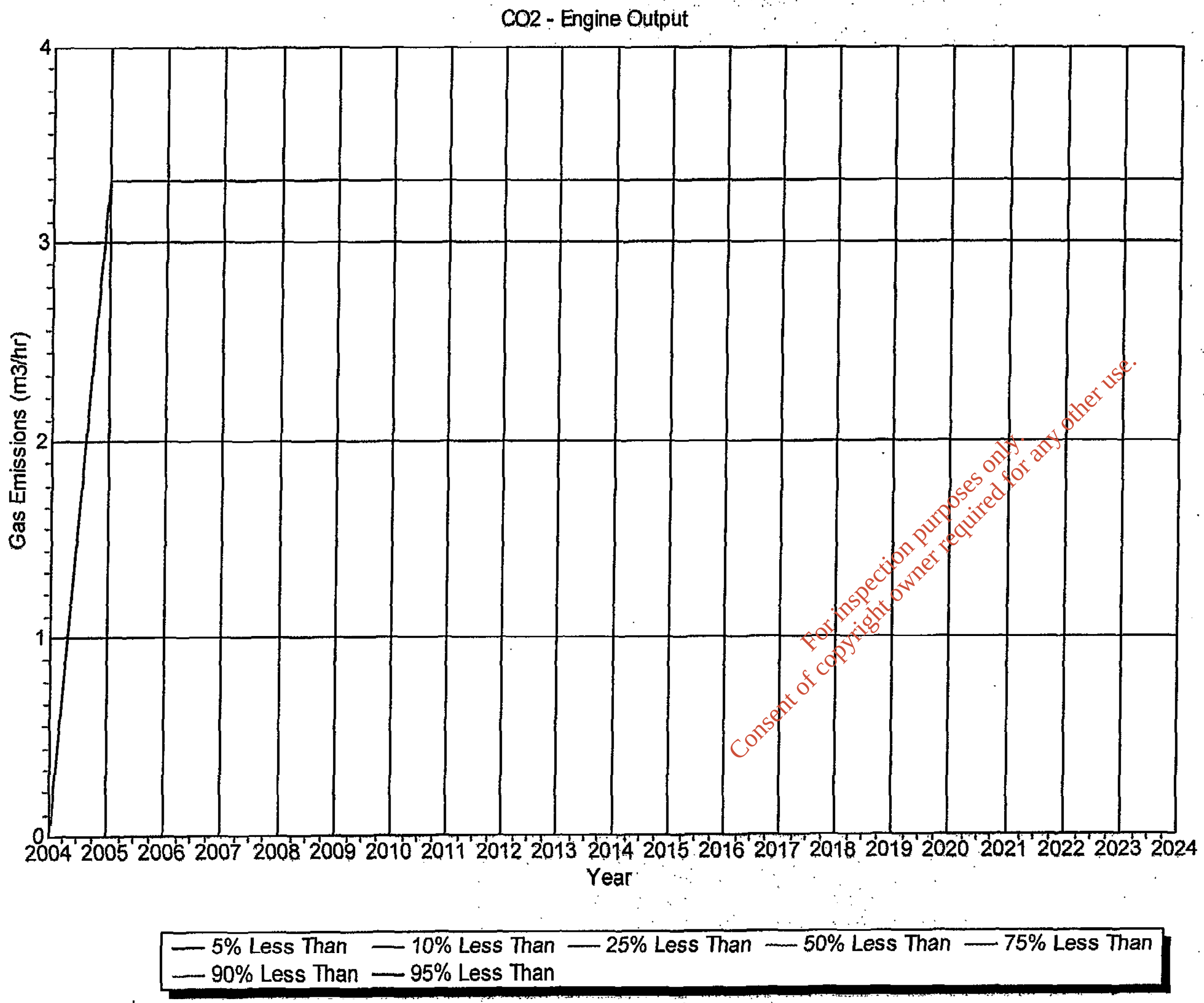
The proportion of different material in waste have been taken from the HELGA framework (Gregory *et al.*, 1999).

APPENDIX E

SINGLE VENT AND GENERATED LANDFILL GAS OUTPUT GRAPHS

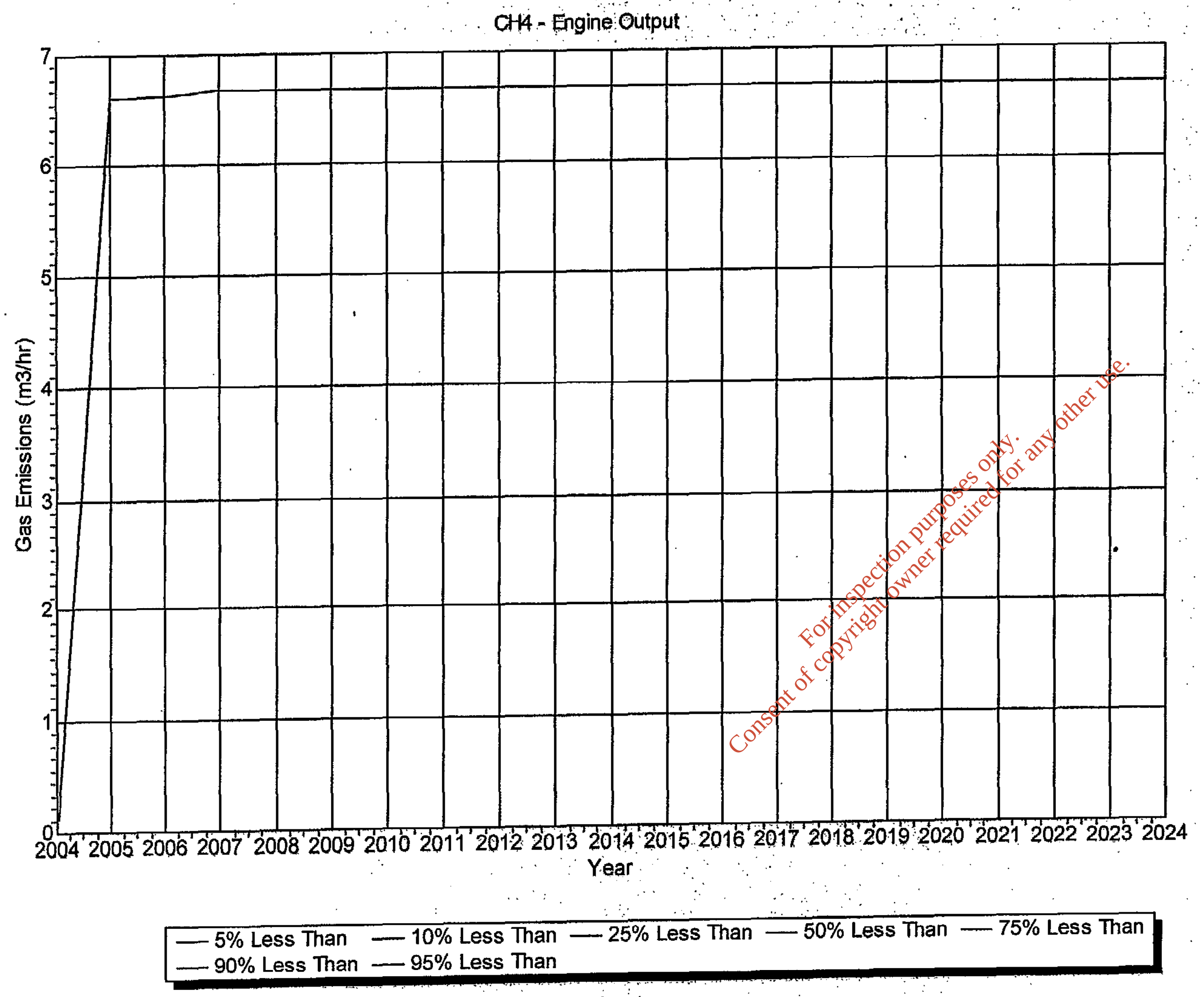
4000043 CRH Blessington

CO2 Output at Single Vent



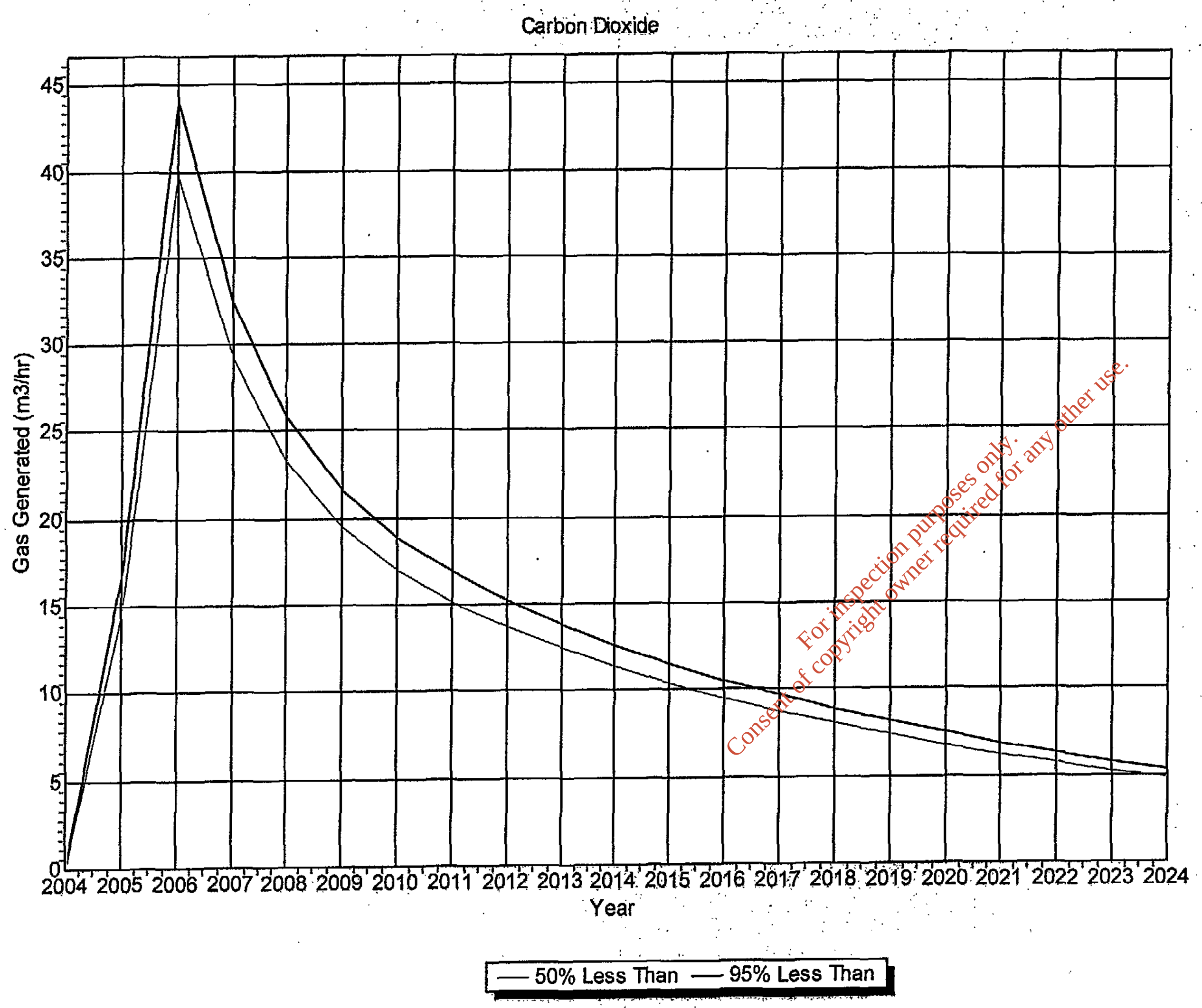
4000043 CRH Blessington

CH4 Output at Single Vent



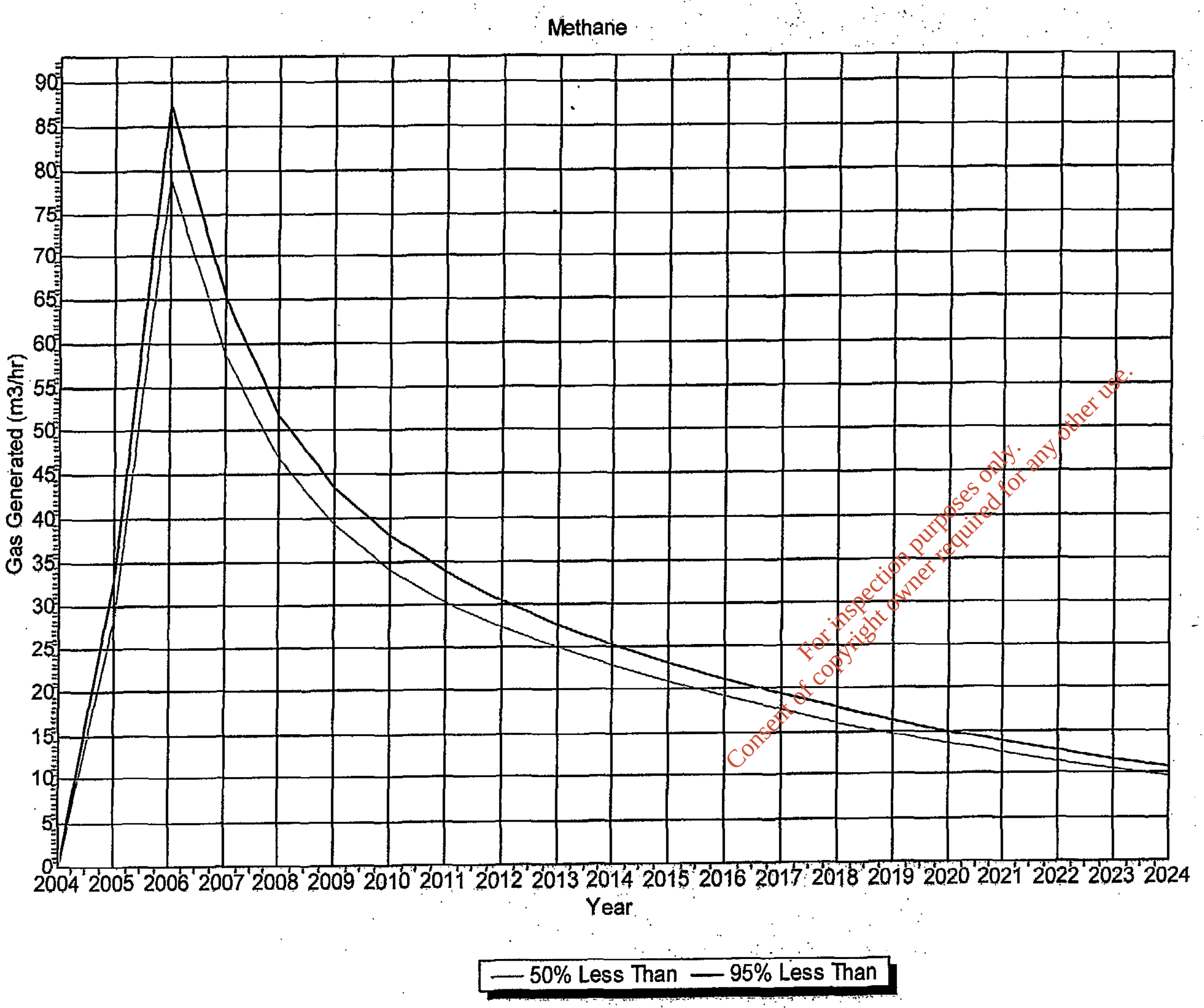
4000043 CRH Blessington

Generated CO2 at Landfill



4000043 CRH Blessington

Generated CH4 at Landfill



APPENDIX F

GasSim TRACE GAS DEFAULT INPUTS FOR ODOUROUS GASES

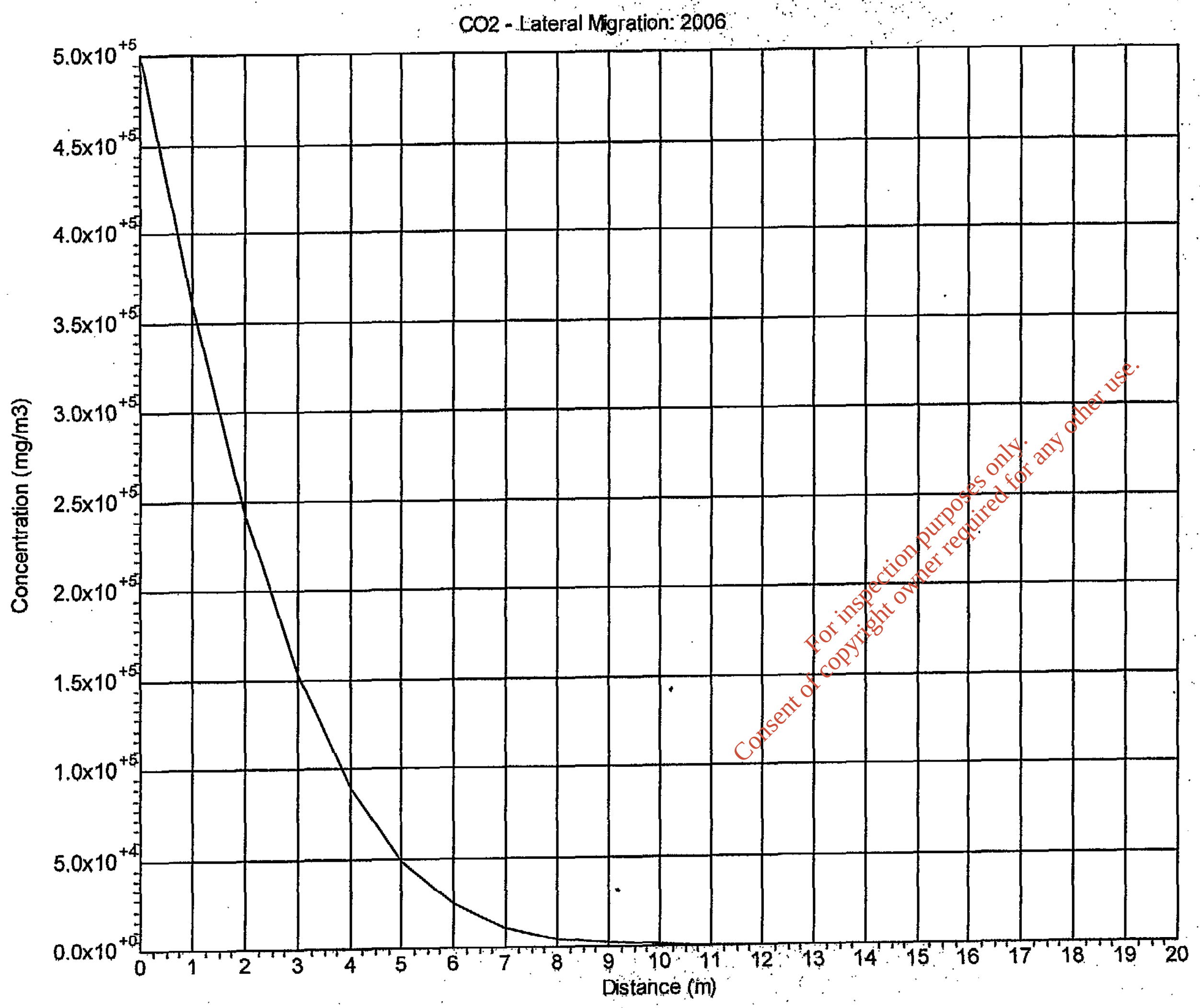
Appendix F	GasSim Trace Gas Default Inputs for Odorous Components of LFG (mg/m3)					
Species	Distribution	Mean or MostLikely	Min	Max	No. ofSamples	
Carbon disulphide	Log triangular	1	1.0´10-2	48	31	
Diethyl disulphide	Log triangular	1	5.0´10-2	1	30	
Dimethyl disulphide	Log Triangular	6.03	2.0´10-2	40	29	
Dimethyl sulphide	Log triangular	24	5.0´10-3	135	55	
Ethanethiol (ethyl mercaptan)	Log triangular	1	2.5´10-1	120	35	
Hydrogen sulphide	Log triangular	1.3	2.9´10-3	97152	99	
Limonene	Log triangular	85.11	2.0´10-1	640	65	
Methanethiol (methyl mercaptan)	Log triangular	1.0´10-1	5.0´10-3	430	46	
Propanethiol	Log triangular	1	5.0´10-2	29.8	39	
Sulphide, total simulations with H2S	Log triangular	3.8	2.9´10-3	97152.4	113	
Sulphide, total simulations without H2S	Log triangular	30.9	1.0´10-2	682.8	64	
Toluene	Log triangular	195	2.2´10-3	1700	121	
Xylene (all isomers)	Log triangular	128.8	4.0´10-4	1100	147	
Odour Units {Predicted} (Ou/m3)	Triangular	50,000	125,000	250,000	Estimated	

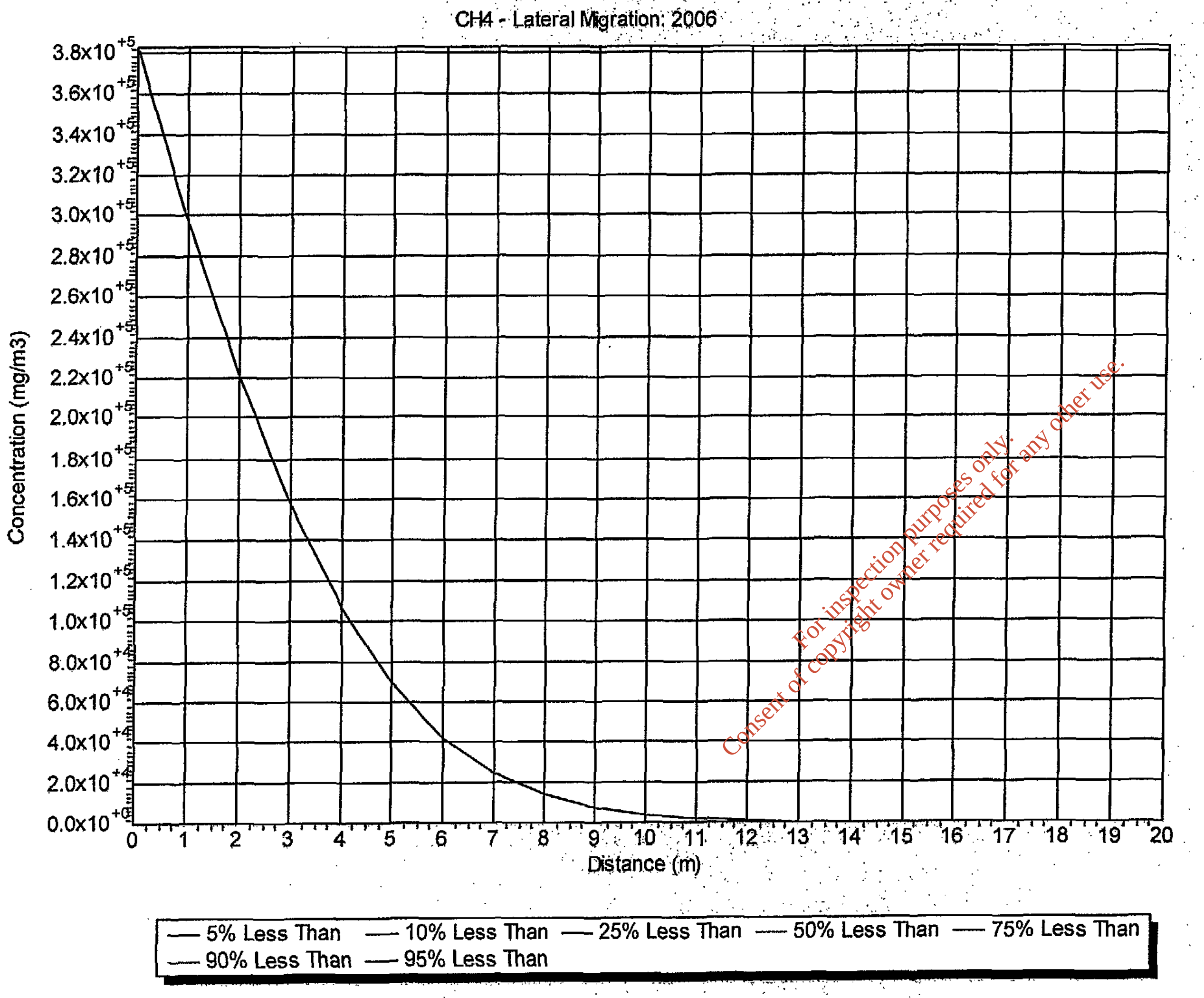
APPENDIX G

LATERAL MIGRATION GRAPHS

4000043 CRH Blessington

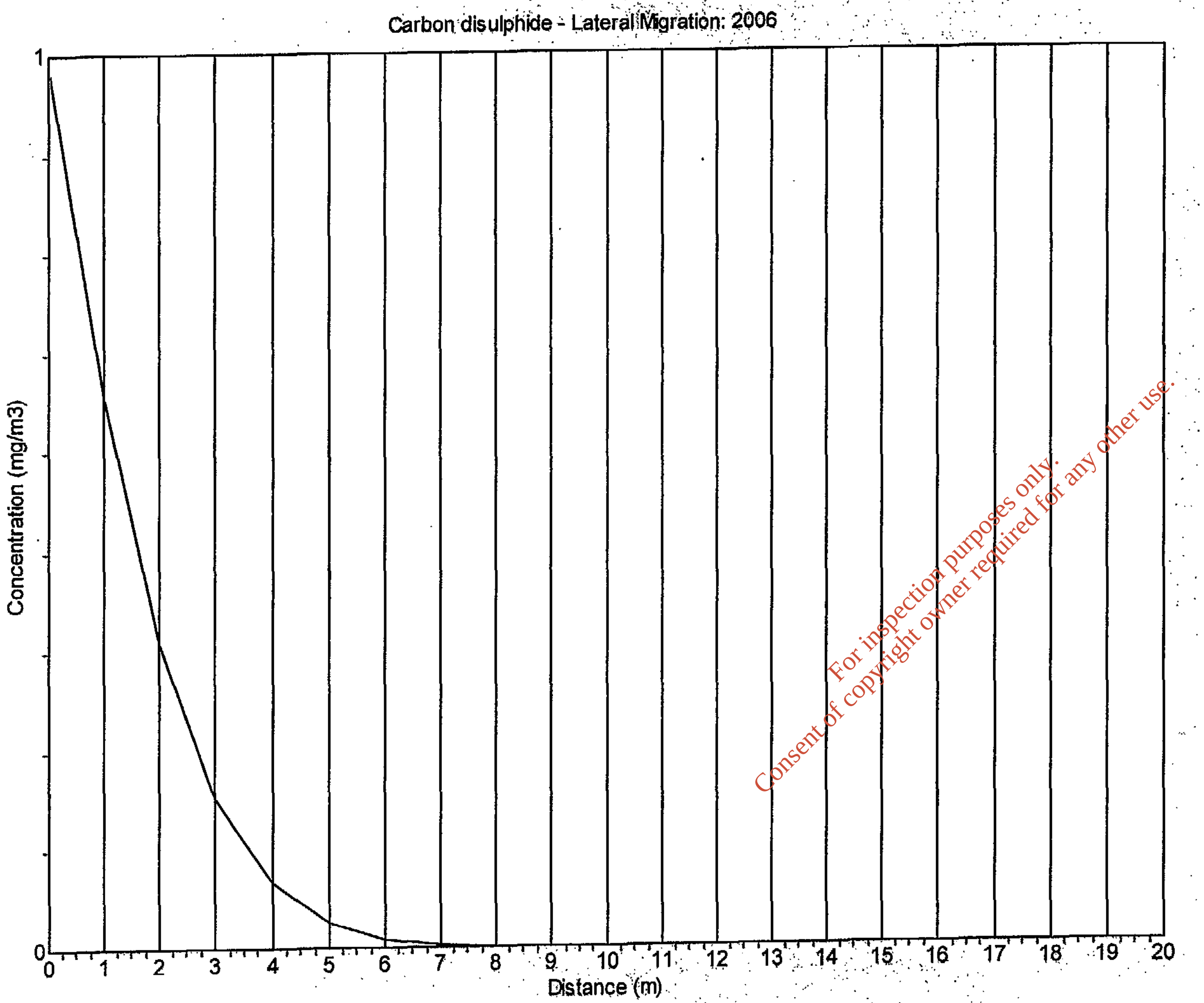
Lateral Migration of CO_2





4000043 CRH Blessington

Lateral Migration of CH4

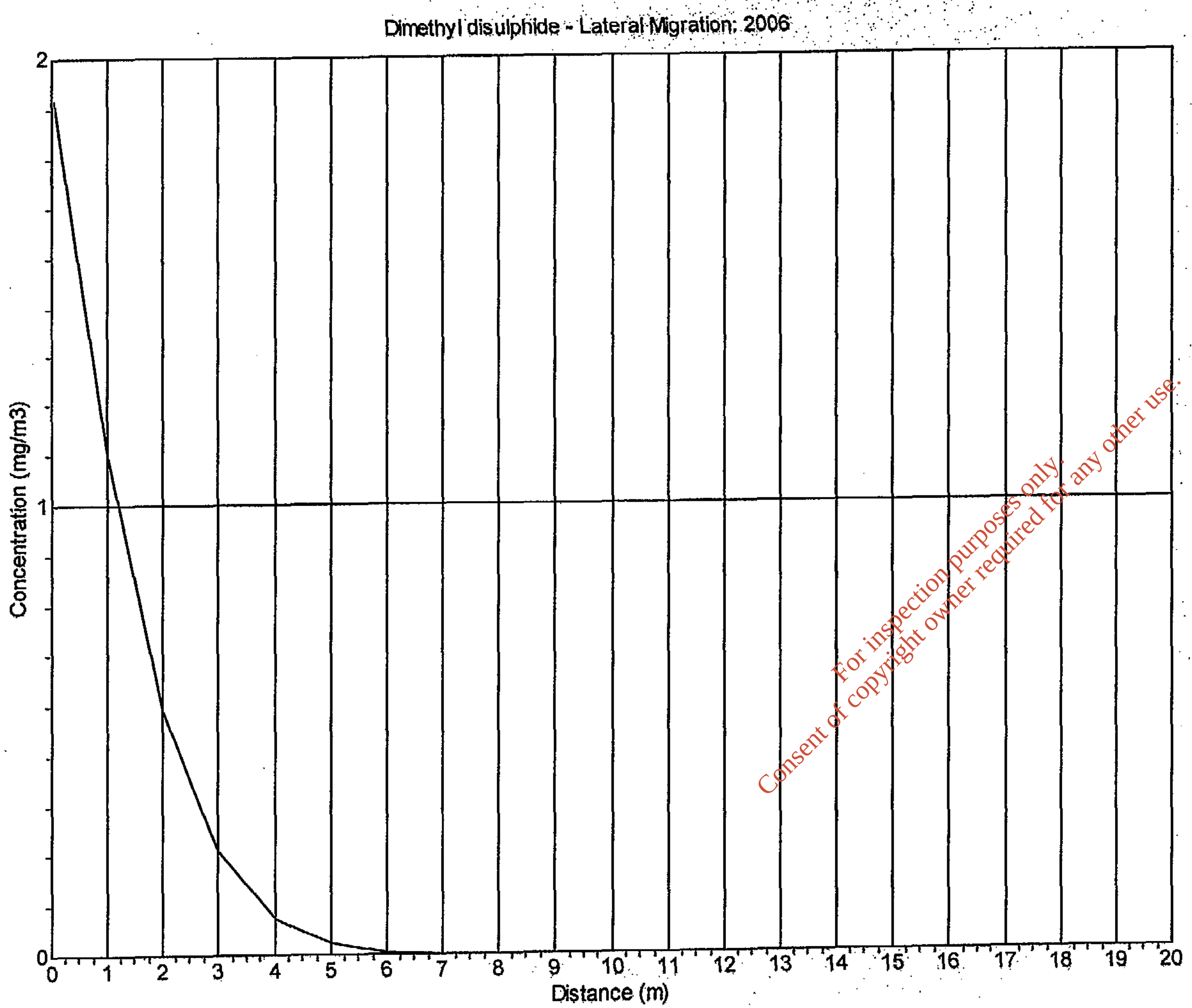


4000043 CRH Blessington

Lateral Migration of Carbon Disulphide

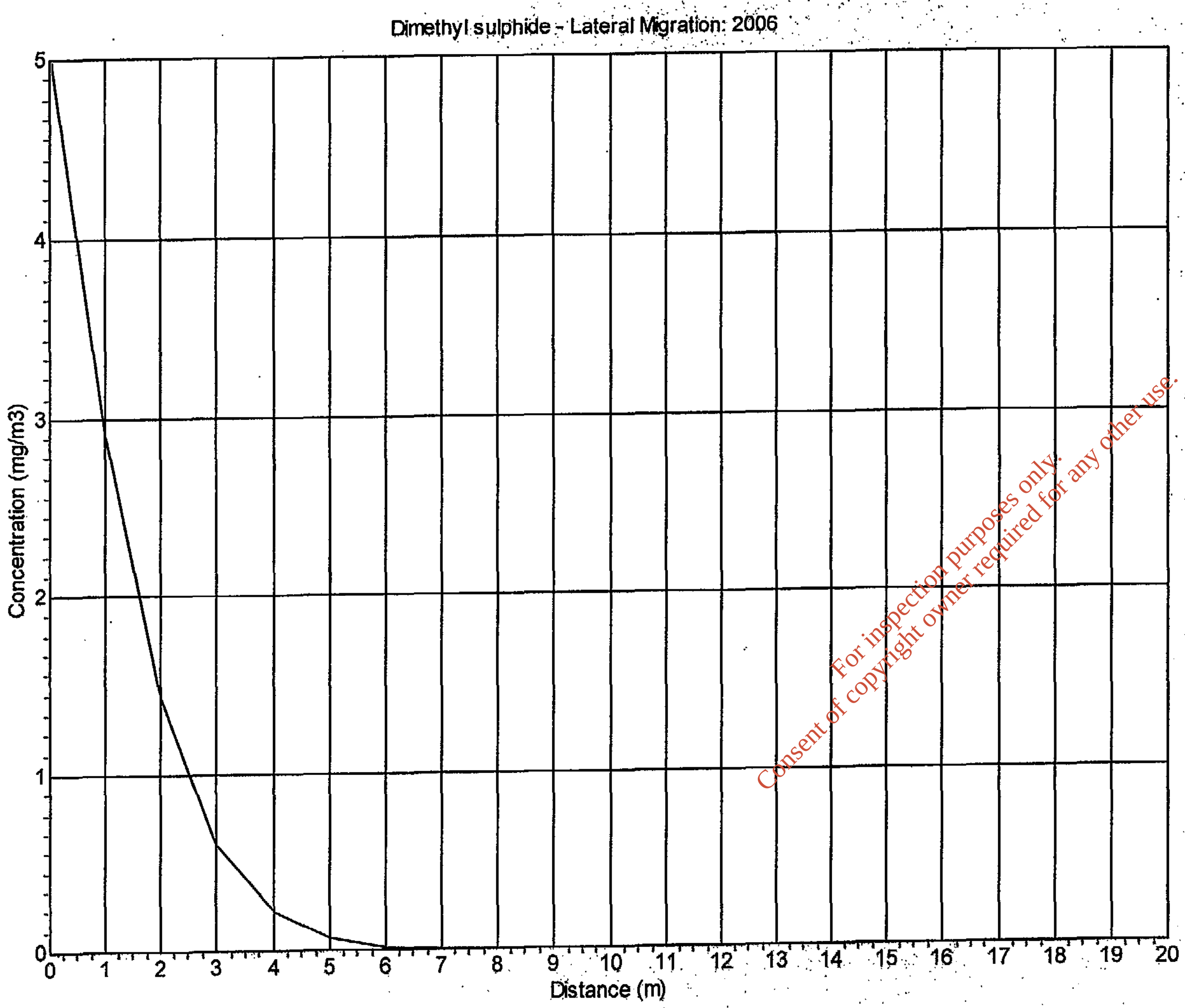
4000043 CRH Blessington

Lateral Migration of Dimethyl Disulphide



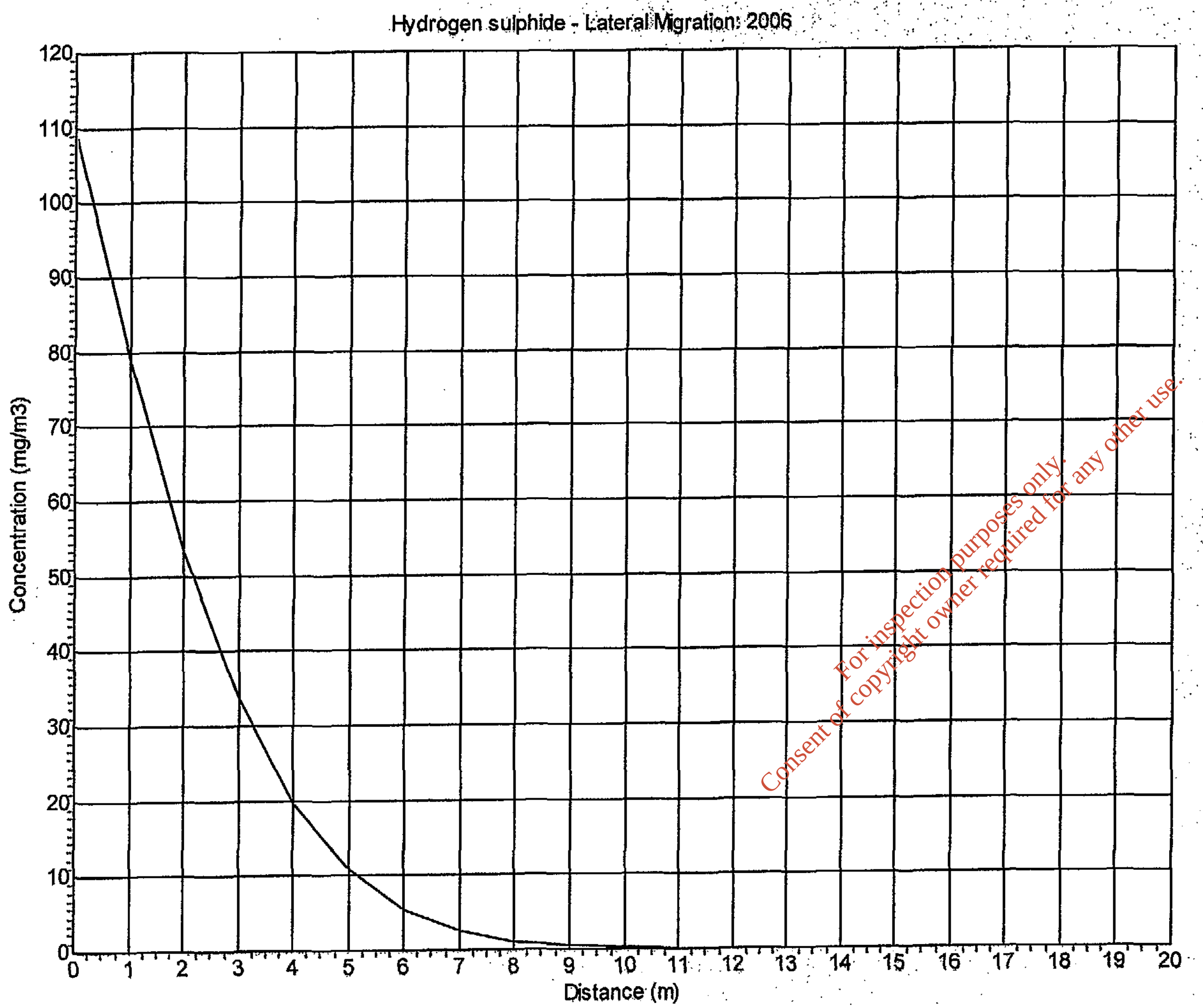
4000043 CRH Blessington

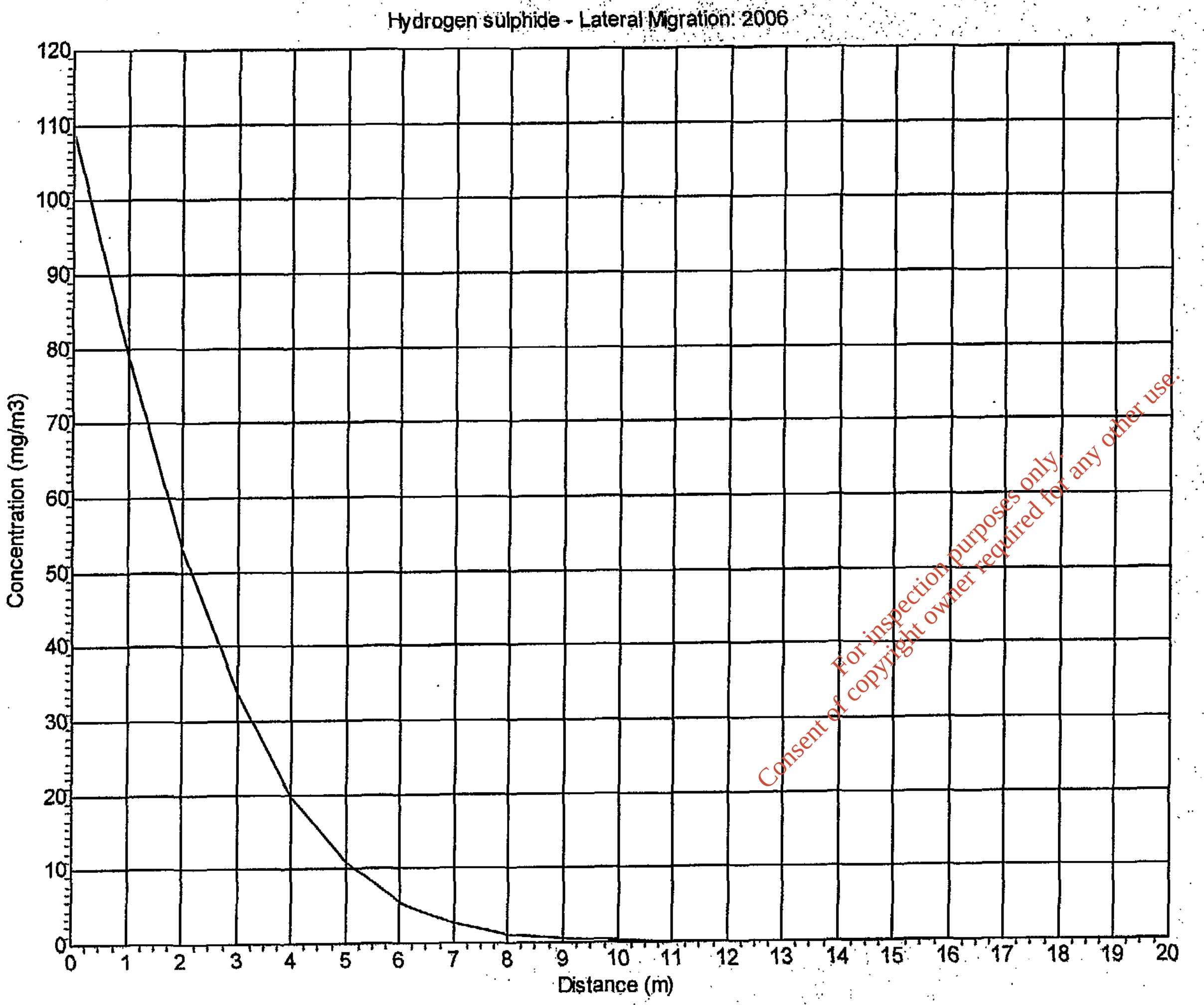
Lateral Migration of Dimethyl Sulphide



4000043 CRH Blessington

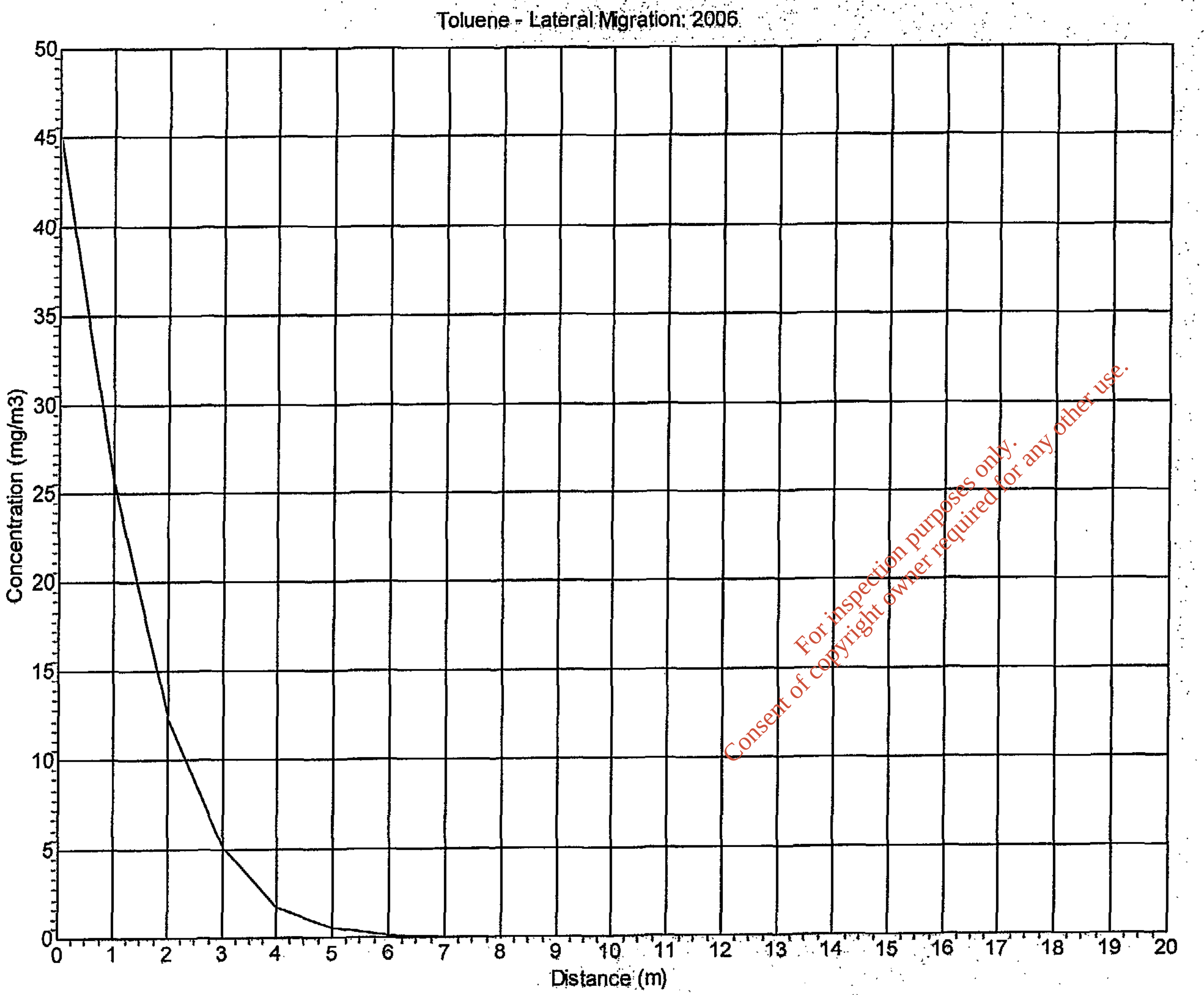
Lateral Migration of Hydrogen Sulphide





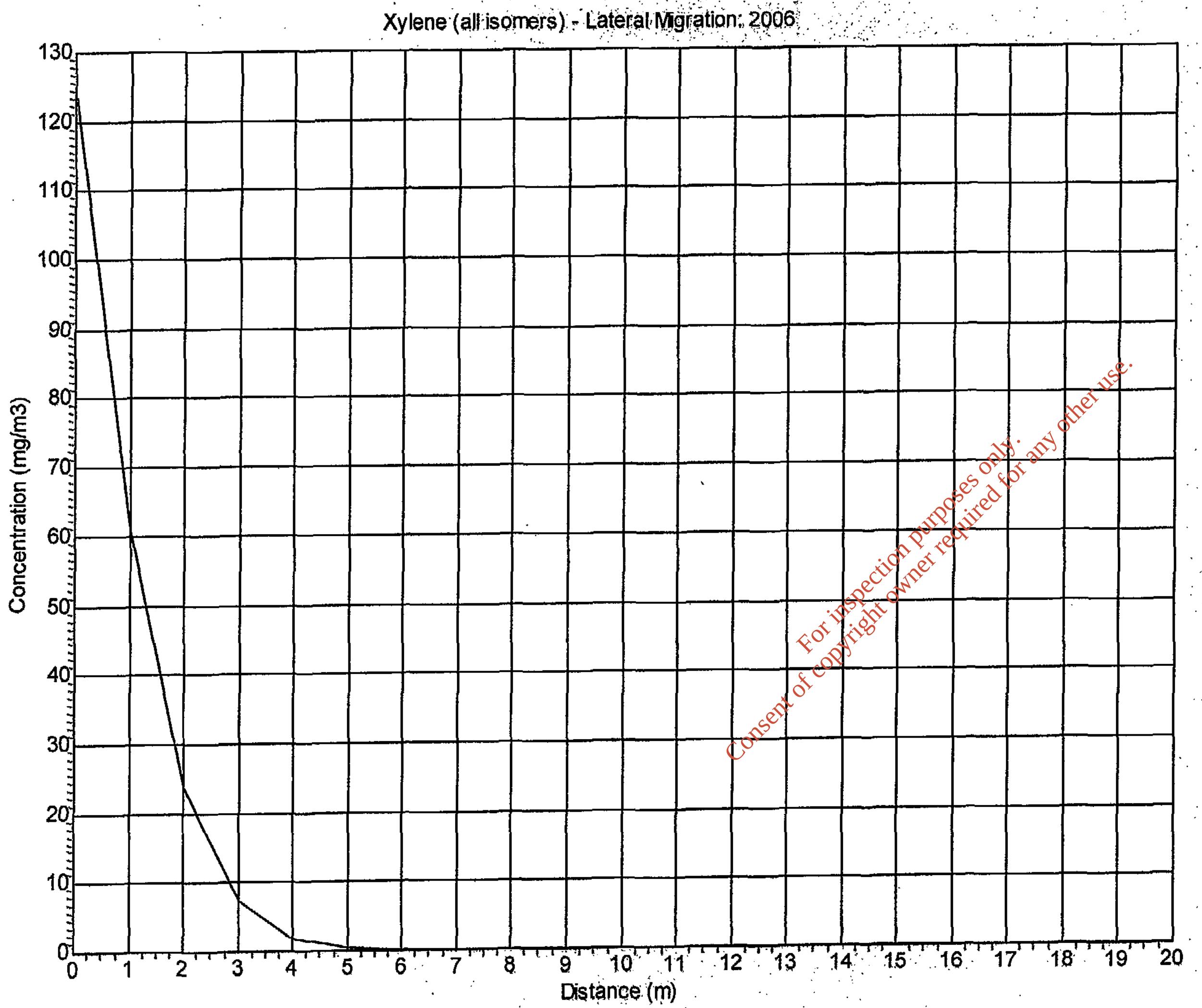
4000043 CRH Blessington

Lateral Migration of Hydrogen Sulphide



4000043 CRH Blessington

Lateral Migration of Toluene



4000043 CRH Blessington

Lateral Migration of Xylene