Newhurst Integrated Waste Management Facility

Newhurst Quarry, Shepshed, Leicestershire

Biffa Waste Services Ltd

Appendix 7.3

Landfill Gas Generation & Risk Assessment

Prepared by:	Authorised by:
D Willey	A Hashm
Consultant	Director of Human Health
December 2006	December 2006

Conrad House
Beaufort Square
Chepstow
Monmouthshire
NP16 5EP

Tel : 01291 621821
Fax : 01291 627827
Email : rpssw@rpsgroup.com

JER7063/AQ
Revision: 2
March 2007

Contents

Tables, Figures & Appendices

Tables

Figures

Appendices

1 Introduction

1.1 General

1.1.1 BIFFA Waste Services Limited commissioned RPS Planning, Transport and Environment (RPS) to undertake a Landfill Gas Risk Assessment for their proposed landfill within an Integrated Waste Management Facility at Newhurst Quarry in support of a planning application and a PPC permit application.

1.1.2 The Charnwood quarry complex is located on the northern edge of Charnwood Forest, either side of the M1 motorway and immediately south of Junction 23. The complex consists of two linked quarries including Newhurst and Longcliffe. The proposal for the development of the Integrated Waste Management Facility (including the landfill) is confined to Newhurst Quarry.

1.1.3 The landfill will be engineered with a full lining system which will consist of a base lining and a wall lining system adapted to the shape of the quarry and its steep sides.

1.1.4 Landfilled waste will be progressively deposited in layers. In the later stages when the layers will cover large areas, portions will be temporarily capped pending subsequent filling over them. The wall lining system will be installed progressively as the level of fill rises.

1.2 Conceptual Landfill Gas Site Model

1.2.1 The landfill gas risk assessment has been undertaken using GASSIM version 2.0. The model input data is discussed further in this section.

Sources

1.2.2 Biffa Waste Services Ltd (Biffa) are proposing to develop an Integrated Waste Management Facility at the former Newhurst Quarry site in Shepshed, Leicestershire. The facility will have an overall capacity of approximately 375,000 tonnes per annum (tpa) with supporting bulking and related infrastructure. The landfill would accept approximately 275,000 tonnes/annum of non hazardous waste and would have a capacity of approximately 6 million cubic metres, sufficient to last approximately 20 years depending on the amount of waste recycled or recovered.

1.2.3 The quarry void is to be engineered to accept non-hazardous waste. The engineering will comprise a containment barrier conforming to the minimum requirements of the Landfill Regulations in terms of equivalent thickness and hydraulic permeability.

1.2.4 Dewatering of the surrounding bedrock will be continued to permit installation of the basal liner in the dry. A sub basal groundwater drainage layer will facilitate the continued dewatering of the void. Landfill Regulation compliant sidewalls will be constructed in sections each lifting the engineered volume in stages to progressively release additional volume for landfilling. Landfilling will be undertaken in a cellular manner to allow leachate generation by infiltration to open waste to be minimised.

1.2.5 Following completion of the engineering works; the landfill will be operated as a sub-water table facility using the principal of hydraulic containment to maintain an inward hydraulic head gradient to prevent potential leachate migration out of the waste mass. This will be achieved by artificially maintaining an external groundwater head marginally above that of the internal leachate elevation within the waste mass. Leachate removal, treatment and disposal will be undertaken to maintain this condition as required.

1.2.6 As landfilling continues, groundwater dewatering rates will be reduced to allow groundwater and thus leachate levels within the waste to rise so maintaining hydraulic containment throughout the landfilling phase of the engineered quarry void prior to final restoration. Restoration will comprise a low permeability cap to minimise infiltration and associated generation of leachate. Leachate control and treatment measures will continue as required as part of post closure management following cessation of dewatering and restoration of natural groundwater levels around the completed landfill.

1.2.7 To utilise the landfill gas from the site a gas collection and management system will be installed with 3 gas engines and 2 flares in operation with gas engines being the preferential source of landfill gas treatment, with flares as a back-up in periods of engine shut-down, or to burn any surplus gas. These will give rise to additional sources of gases to the atmosphere as a result of combustion.

Pathways

1.2.8 Receptors may be exposed to landfill gas emissions through:

- Direct release to atmosphere
- Sub-surface migration through the ground or along service ducts and/or pipelines etc
- Indirect release to atmosphere (e.g. from sub-surface landfill gas migration)
- Direct release of combustion products to atmosphere (e.g. flares and engines).

1.2.9 This site has both gas engines and flare systems. Therefore the main pathways of exposure will be from the emissions of the gas engines and flares, the direct surface release to atmosphere and the sub-surface migration. However the active gas collection system is designed to ensure that lateral migration is prevented or reduced to insignificant levels.

Receptors

1.2.10 The EA has identified a number of potential receptors that need to be considered with respect to landfill gas. The generic categories are listed below.

- Domestic dwellings (human occupation closer than 50 m, and between 50 and 500m
- Hospitals
- Schools and colleges;
- Offices, industrial units and commercial premises;
- Sensitive habitats and environmental areas e.g. SSSIs;
- Public footpaths or bridleways;
- Major highways and minor roads;
- Open spaces, parks and farmland (crop damage); and·
- Air quality management zones.

1.2.11 The EA state that the conceptual model should identify the site-specific examples of these and that it may be useful to group receptors together where the risks are likely to be the same (e.g. a particular street or small group of houses).

1.2.12 There are a number of sensitive receptors within 500 metres of the site boundary including residential properties and farms. These are shown in Table 1 below.

Table 1: Sensitive Receptors Near Newhurst Landfill Site

Receptor name	GasSim ID	Reference	Distance and direction from boundary	Exposure assessment scenario
Ingleberry Road	RE05	1	144 metres West	Residential
Fairway Road South	RE11	2	148m North West	Residential
Nook Farm	RE14	5	253m Northeast	Residential
Hurst Farm	RE01	8	412m East	Residential
Shortcliff Farm	RE10	11	369m South	Residential
Ingelberry Lodge Farm	RE02	12	40m Southwest	Residential
Ingelberry House Farm	RE03	13	64m Southwest	Residential
Morley Farm	RE13	14	383m West	Residential

1.2.13 There are also a number of industrial units within 500 metres of the site boundary, these are detailed in Table 2.

Table 2: Non-Sensitive Receptors Near Newhurst Landfill Site

Receptor name	GasSim ID	Distance and direction from boundary of landfill
Industrial units off Ashby Road East	RE06, RE07, RE08	12 and 18 metres North/Northeast
Cow Hill industrial units	RE09	34m Northeast
The industrial units off the B5330	RE12	216m North
The industrial depot	RE16	31m North
Charnwood Quarry	RE18	373m Southeast

1.2.14 The exposure module within GasSim allows for four different critical groups:

- Residential receptor with plant uptake·
- Residential receptor without plant uptake
- Allotments
- Commercial and industrial receptors

1.2.15 The exposure assessment assigned to each receptor is presented in Table 1.

1.2.16 There are no schools, colleges or hospitals within 500m of the site.

1.2.17 The private homes and farms described above have been considered for the exposure assessment in GasSim. GasSim assumes that the homes and farm receptors are children between 0 and 6 years old.

2 Landfill Gas Risk Assessment

2.1 The Nature of the Landfill Gas Risk Assessment

2.1.1 The model GasSim was used to undertake this assessment. The Environment Agency developed GasSim as a platform to assist risk management decision about landfill gas as part of the planning, regulation and operational aspects of a landfill site. Therefore it can be used as a tool for different purposes including assessing the risks from current or planned landfill gas emissions.

2.1.2 The model can be tailored to any individual landfill site as the user can define the mix, composition, biodegradability, moisture content of the waste and other parameters. This information is then used to estimate the generation of landfill gas at the site for any period up to 150 years in to the future. The model also makes allowance for the diverse rates of degradation of different waste components.

2.1.3 Landfill gas flux to the environment (for bulk and trace components) is then calculated, taking into account gas collection, flaring and biological methane oxidation where applicable.

2.1.4 The latest versions of GasSim includes a built-in Tier 1 screening method to identify gases whose emissions are insignificant and which gases may require detailed modelling.

2.1.5 The Environment Agency's Horizontal Guidance Note IPPC H1 " Environmental Assessment and appraisal of BAT" Version 6 (July 2003), describes a method for screening out insignificant emissions to air that are not required to be modelled further.

2.1.6 GasSim latest versions use this methodology to determine whether surface, engine and flare emissions for each modelled gas are insignificant.

2.1.7 At the screening stage the model undertakes the following:

- Calculates the contribution from each process to the concentration of gas at a receptor,
- Determines whether the process contribution is beneath a certain threshold, and, therefore insignificant,
- Determines whether the process contribution is above a different threshold so that more detailed modelling is required.

2.2 The Proposed Assessment Scenarios

Lifecycle Phases

2.2.1 The different stages of the landfill's life cycle are required to be considered in order to take into account the effects of any changes that may occur with time. This may include the potential for degradation of, or change in the operation of the landfill gas management system and the effectiveness and integrity of the containment system.

2.2.2 The landfilling on the subject site is a sequential process that will be undertaken progressively in all the cells.

2.2.3 Although the containment systems for phases 1 to 9 (capping and active gas collection system) varies with time for the different cells, this variation has no effect on the total generated gases. However, the proportions of the surface and lateral emissions at any time will vary for the different cells depending on their existing engineering arrangements.

Table 3: Years considered in assessment

Scenario	Years considered	Reasons
Operational period	2019	Year predicted to give maximum surface emissions
Operational period	2016 – 2021	The predicted 6 year period of maximum surface emissions
Maximum gas generation	2031	Year predicted to give maximum landfill gas generation

2.3 The Generated Gases to be Modelled

2.3.1 Beside the UK Air Quality Standards, the Environment Agency present a selection of Environmental Quality Standards (EQSs) and Environmental Assessment Levels (EALs) that can be used at the risk screening stage for typical gases from biodegradable non-hazardous landfills. The EA has also identified key landfill gases to be considered in any risk assessment for a landfill accepting biodegradable waste. These include (but are not limited to) the following compounds:

- Nitrogen dioxide·
- Sulphur dioxide ·
- Carbon monoxide·
- Hydrogen chloride·
- Benzene·

- Vinyl chloride·
- Dichloromethane·
- Tetrachloroethylene

2.3.2 Landfill gas utilisation and flaring systems are combustion processes where landfill gas is used as fuel and air as an oxidant. The emission from combustion systems contain a variety of compounds derived from combustion, unburnt fraction of gas, from materials used in the abstraction and utilisation system and their combustion products, contaminants present in the air used in the combustion and products of synthesis and pyrolysis during combustion.

2.3.3 The primary pollutants from gas utilisation processes are nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs) and particulates.

2.3.4 The gas engines and flares at Newhurst Landfill have been assessed and presented in a separate report taking the worst-case scenario into consideration. The detailed Air Quality Assessment undertaken for the impact from engines and flares is provided in Appendix 7.1 of the Newhurst Environmental Statement.

2.3.5 The impact from odour at Newhurst landfill site will be assessed and presented in another report to allow for inclusion of additional odour source from the proposed composting facility that forms part of the integrated waste management facility. The detailed Odour Assesment for the site is provided in Appendix 7.2 of the Newhurst Environmental Statement and addresses the impact from odour.

2.4 Numerical Modelling

Justification for Modelling Approach and Software

2.4.1 The GasSim model was used for the purpose of this assessment for the reasons discussed in Section 2.1. The highest confidence level of 95% was utilised in the assessment to account for the worse case scenarios. The Environment Agency commonly considers a 95th percentile to be a reasonable assessment level in a GasSim assessment.

Model Parameterisation

2.4.2 Most of the data used to estimate emissions were based on site specific data. These include the infiltration rate, the landfill geometry and engineered controls, the source input and waste composition. However, some of the model default parameters were used in the absence of site-specific data.

2.4.3 The concentrations of the different gases listed in the EA Pollution Inventory were selected and used without modification. This selection is based on confidence in these default data that was compiled by the EA based on gathered information from a large selection of typical landfills in the UK.

2.4.4 There are 9 phases of landfill considered in this assessment; Phases 1 to 9.

Infiltration and Landfill Characteristics

2.4.5 The input value for the infiltration coefficient has been assumed as Uniform with the average range of precipitation shown in Table 4 below.

Table 4: Infiltration Rates Considered In Modelling

	Minimum (mm/year)	Maximum (mm/year)
Uncapped	70	700
Capped	5	7

2.4.6 The proposed filling at Newhurst is to be completed in 9 phases with phases 6, 7, 8 and 9 forming the top cells. Landfilling will start with phase 1a forming part of the bottom layer. Phase 1a will then be covered with a temporary cap whilst phase 1b is filling. Once phase 1b is complete phase 2a will begin covering 1b, phase 2a will then have a temporary cap whilst phase 2b begins filling. Phase 2b will be covered by phase 3, which will have a temporary cap once full. Phases 4 and 5 will then follow. The last 4 phases, namely 6, 7, 8 and 9 will then be completed in order and capped after each phase is complete. Table 5 has the approximate tonnage for each cell. Please see Appendix E for a schematic of the phasing planned at Newhurst landfill site.

Table 5: Proposed Phases At Newhurst Landfill Site And Approximate Tonnage

Phase number	Tonnage
Phase 1a	319000
Phase 1b	173000
Phase 2a	343000
Phase 2b	418000
Phase 3	998000
Phase 4	451000
Phase 5	715000
Phase 6	186500
Phase 7	689500
Phase 8	1108500
Phase 9	598500

Source

2.4.7 The waste breakdown assumed for Newhurst landfill site for Phases 1 to 9 is presented in Table 6.

Table 6: Breakdown Of Waste At Newhurst Landfill Site

Domestic (%)	Industrial (%)	Inert (%)
35	55	10

The waste compositions can be found in Appendix A of the report.

2.4.8 Due to GasSim being unable to model scenarios where cells are over laid this assessment has split the site into 4 phases. The areas of the surface boundaries of phases 6, 7, 8 and 9 have been used to represent the entire site in the modelling process. These boundaries have been extended vertically to the base of the landfill to incorporate all previous phases to create the modelling cells.

2.4.9 The approximate landfill area for Newhurst for each cell is as follows:

- Phase 6 – 17800m2·
- Phase 7 – 23600m2·
- Phase 8 – 28000m2·
- Phase 9 – 41900m2

Methane and Carbon Dioxide Concentrations

2.4.10 As there is no site-specific gas composition information data available, the GasSim default concentrations of methane and carbon dioxide have been assumed.

Cellulose

2.4.11 Defaults values in GasSim have been used for the decay rates assuming wet conditions.

Waste Moisture Content

2.4.12 The waste was modelled as wet (moisture content 60 – 80%) with the density assumed to be (0.8, 1.2) tonnes m^3. Using the engineering design detail information, the leachate head was estimated (Table 7) for the different phases through the life of the cells depending on their depth.

Table 7: Calculated Leachate Head Used In Assessment.

	Minimum	Maximum
Phase 6	1	23
Phase 7	1	54
Phase 8	1	60
Phase 9	1	9

GasSim default values have been used where actual data is unavailable.

Trace gases

2.4.13 Defaults values in GasSim have been used for the trace gas concentrations in landfill gas giving a conservative approach to the assessment.

Gas plant

2.4.14 The gas engines and flares at Newhurst Landfill have been assessed in a separate report to allow for a worst-case scenario to be taken into consideration. Please see Appendix 7.1 of the Newhurst Environmental Environmental Statement for the Detailed Air Quality Assessment undertaken for the impact from engines and flares.

Odour

2.4.15 Due to the additional source of odour from the proposed composting facility that forms part of the integrated waste management facility. The impact from odour at Newhurst landfill site will be assessed in a separate report. Please see Appendix 7.2 of the Newhurst Environmental Statement for the Odour Assessment undertaken for the impact from odour.

Lateral migration

2.4.16 The data inputs for the Geosphere in GasSim have been derived from values for the rock type associated with the site. The parameters used in the modelling are:

- Moisture content of 0 to 15% and
- Porosity of 17 to 35%.

2.4.17 Sub-surface migration of landfill gas may occur from the site. A quantitative assessment of the risks associated with the lateral migration of landfill gas has been undertaken in section 'Sub-surface Migration and Vegetation Stress' below.

Sensitivity Analysis

2.4.18 GasSim is a probabilistic model and the basic idea in all probabilistic assessments is that a probability can represent a judgement about uncertainty.

2.4.19 When using GasSim, the uncertainties are dealt with by insuring that the conceptual model used and the assumptions made in the equations are representative of the environmental regime at the site, and by making decisions based upon an appropriate probability of outcome. Parameter uncertainty is dealt with by allowing specification of a range of values for input parameters where appropriate rather than a single number.

2.4.20 GasSim was run for the probability of the gas utilisation plant failing. The model predicted that such a scenario would lead to a significant increase in the surface and lateral emissions of landfill gas as shown in Figure 4 whilst reducing the amount of pollutants associated with the combustion of landfill gas. The results from the sensitivity analysis are discussed further in section 'Sub-surface Migration and Vegetation Stress' below

2.5 Risks to the Environment

Landfill Gas Emissions

General

2.5.1 The model was used to predict the present and future gas production rates for 150 years of the landfill life. It predicted that the landfill will produce a sufficient flow rate of landfill gas to justify the use of gas engines and flares.

- The maximum landfill gas generation – 1710m³/hr in 2031
- The maximum surface emissions of landfill gas - 759m³/hr in 2019

2.5.2 The surface emissions from the site were estimated by Tier 1 of the model for key landfill gases. The model details and the results of the assessment for the most critical years are presented in Appendix D and the main pollutants are briefly described in the following text.

Table 8: Tier 1 Results For Highest Years Of Surface Emissions

Worst year	Pollutant	Short-term		Long term	
		Is the emission insignificant	Require detailed modelling	Is the emission insignificant	Require detailed modelling
2012	Benzene - surface	yes	no	no	no
	CO	yes	no	NA	NA
	Dichloromethane	yes	no	yes	no
	NOx *	NA	NA	NA	NA
	SO2 *	NA	NA	NA	NA
	Tetrachloroethylene	yes	no	yes	no
	HCl *	NA	NA	NA	NA
	Vinyl chloride	no	no	no	no
2019	Benzene - surface	yes	no	no	no
	CO	yes	no	NA	NA
	Dichloromethane	yes	no	yes	no
	NOx *	NA	NA	NA	NA
	SO2 *	NA	NA	NA	NA
	Tetrachloroethylene	yes	no	yes	no
	HCl *	NA	NA	NA	NA
	Vinyl chloride	no	no	no	no

These gases are a result of the combustion of landfill gas and therefore have no surface emission associated with them.

2.5.3 In Tier 1 of GasSim, the first step of the assessment, namely assessing the significance of the gaseous emission is based on the following criteria:

- Long-term ground level contribution at the considered receptor are below 1% of the long term EAL or EQS
- Short-term contribution is below 10% of the short-tern EAL or EQS.

2.5.4 The EA H1 document states that the second step is to be undertaken for all the emissions that are not screened out in the first step.

2.5.5 The requirement for detailed modelling (second step) however is based on the following:

- The long-term contribution when added to the background concentration is > 70% of the long-term EAL or EQS
- The short-term contribution when added to 1/5 of the background concentration is >20% of the short term EQS or EAL.

2.5.6 Where the emission is considered to be potentially significant and the gas emission fails the second step of the assessment for either the short term or long term assessment then the results indicate that further modelling is required.

2.5.7 Furthermore H1 states that detailed assessment of short-term effects is often complex. The maximum process contribution and maximum background contribution may be separated both temporally and spatially, such that the addition of the two “worst case” short-term concentrations together does not represent a likely occurrence. The error in estimating short-term releases can also be a factor of 4 to 5. Therefore, a pragmatic approach is suggested that unless the short-term PC exceeds 30% of the short term EAL then the emissions may be considered to be tolerable and that detailed modelling may not be needed.

2.5.8 It can be seen from the results presented in table 8 that none of the modelled gases require further assessment as they all fall below the screening criteria.

2.5.9 It should also be noted that all the above-discussed results were based on the highest concentration at the boundaries of the site. Significantly lower concentrations were identified at the nearest receptors.

Sub-Surface Migration and Vegetation Stress

GasSim predictions

2.5.10 The GasSim model takes a simplified approach to predicting lateral migration assuming that gas migration through the subsurface occurs effectively in the horizontal plane and neglects buoyancy driven gas flow and temperature through the vertical.

2.5.11 Trigger levels of 1% for methane and 1.5% for carbon dioxide have been used to assess the impact from lateral migration of bulk gases at the closest sensitive receptor.

2.5.12 The impact from lateral migration for methane and carbon dioxide at the nearest receptor for phase 6 for the year with the highest landfill gas generation (2022) is predicted to have little or no impact at the receptor. This is the same for phases 7, 8 and 9 of the site.

2.5.13 The results from the lateral migration assessment for the proposed Newhurst landfill demonstrate that risk of migration of bulk landfill gases at the nearest receptors is not of potential significance. Figures 1, 2 and 3 for CH_4, CO_2 and LFG respectively demonstrate the effect the engines and flares have on the lateral emissions and therefore the lateral migration over time. Figures 5, 6 and 7 demonstrate the low concentration of methane, CO2 and total landfill gas at close distances from the site boundaries.

2.5.14 A sensitivity analysis was carried out to identify the effect of the failure of the gas collection system on the lateral migration. Figure 4 has the predicted lateral migration if the gas collection system were to fail. The assessment found that under such a scenario the methane emission is increased by a factor of 1.5 at the nearest receptor. Although there is predicted to be an increase, the concentration at the nearest receptor is still well below the 1% trigger level for methane.

2.5.15 At the nearest receptor carbon dioxide is increased by a factor of 2 with no gas utilisation plant. Although there is predicted to be an increase, the concentration at the nearest receptor is still well below the 1.5% trigger level for carbon dioxide.

Figures:

Figure 1: Total Lateral Emissions Predicted To Occur For Methane

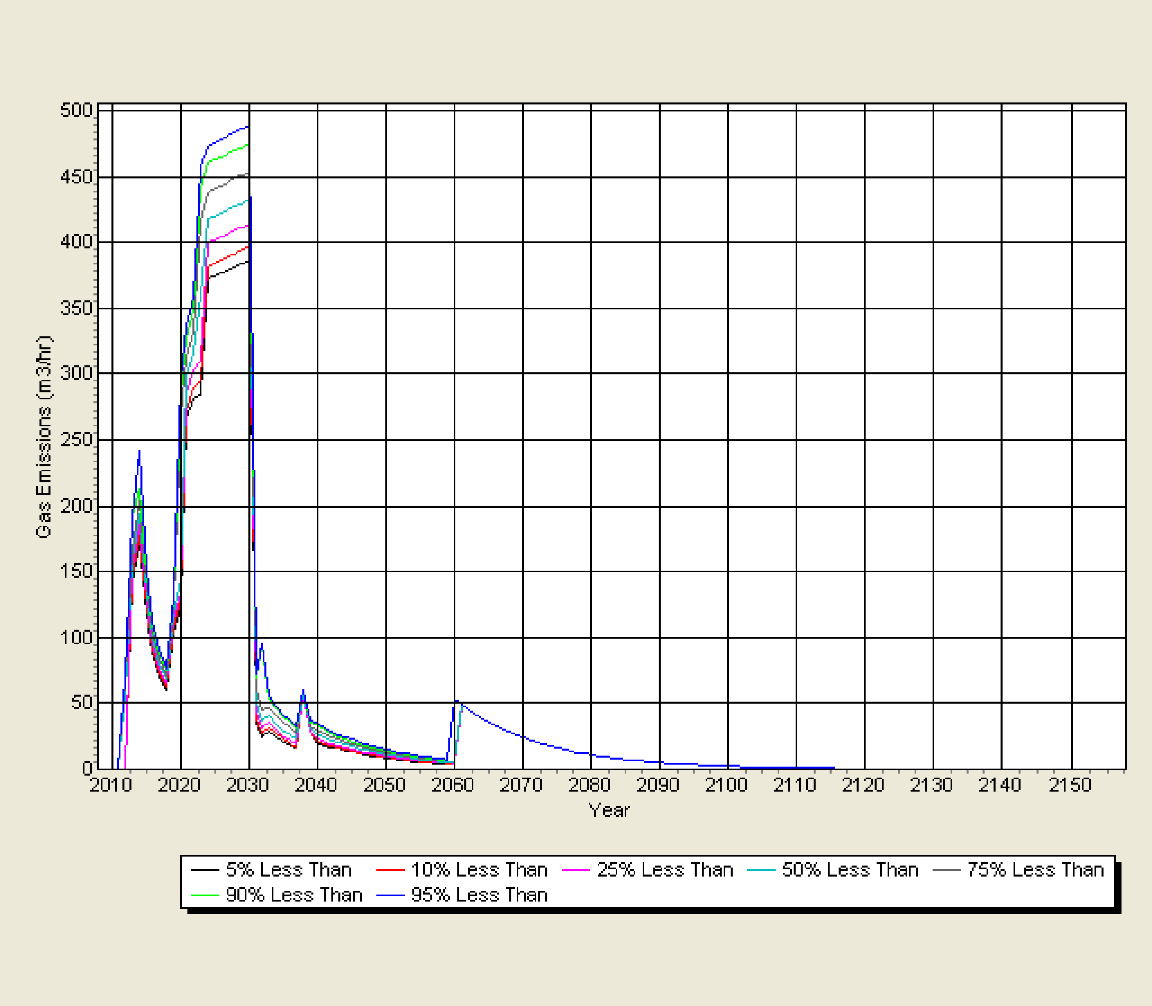


Figure 2: Total Lateral Emissions Predicted To Occur For Carbon Dioxide

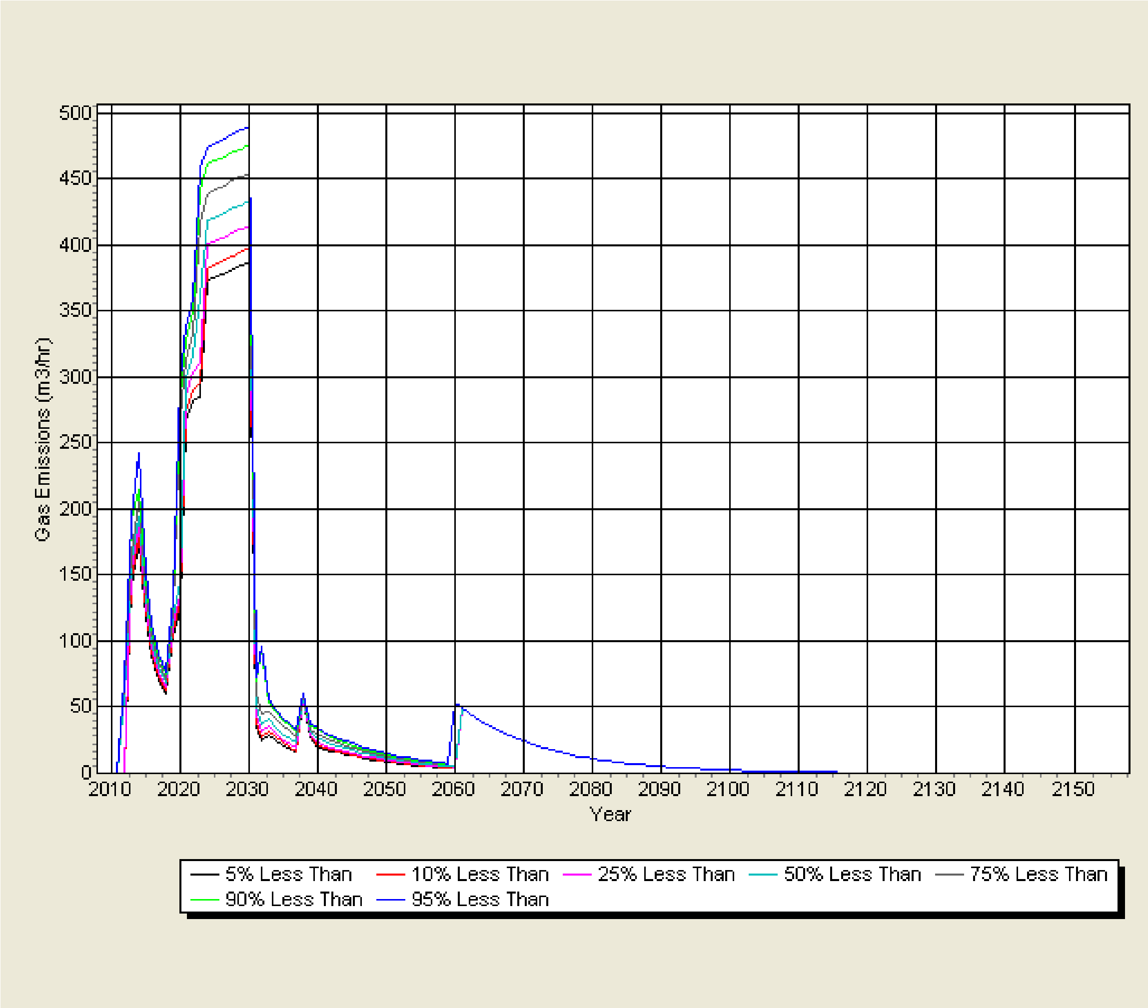


Figure 3: Total Lateral Emissions Predicted To Occur For Landfill Gas

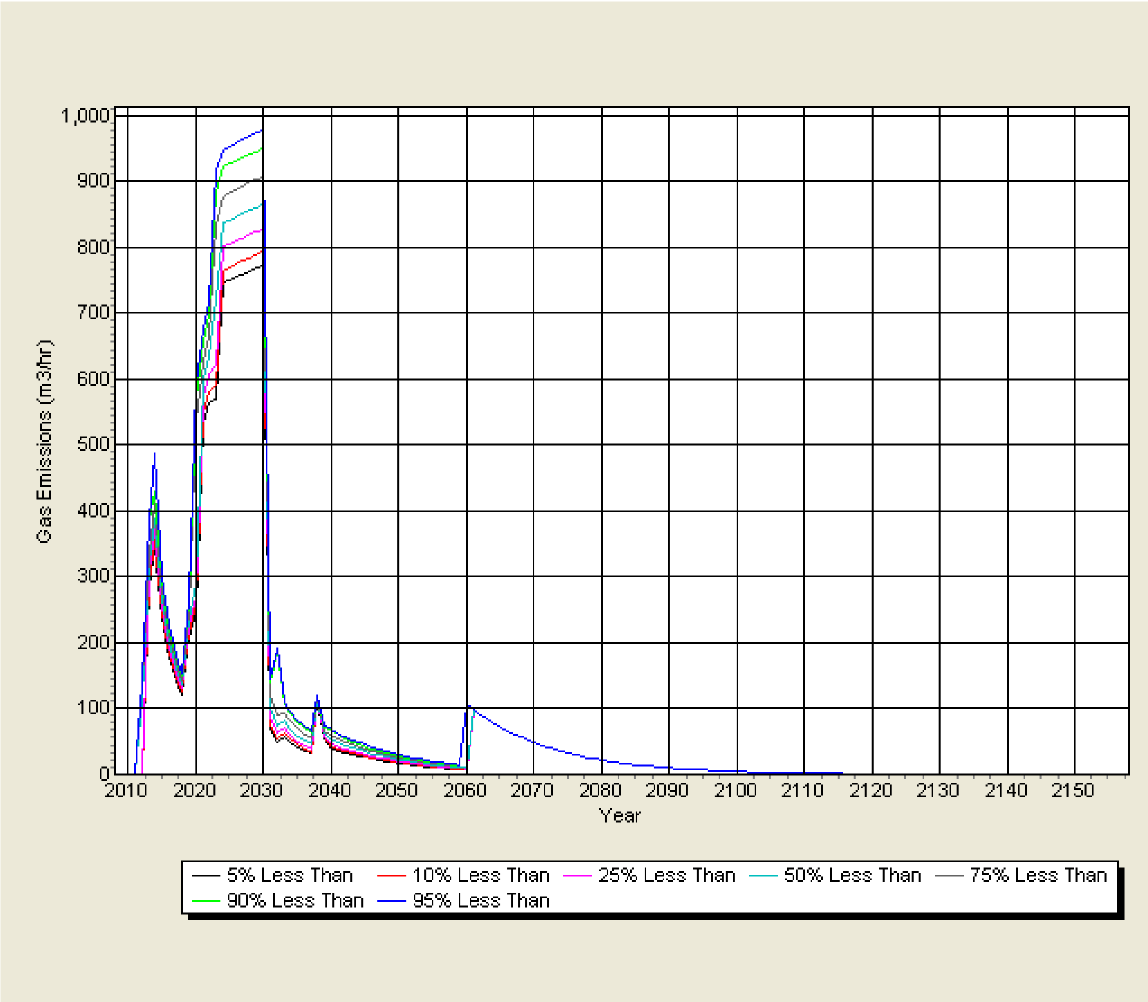
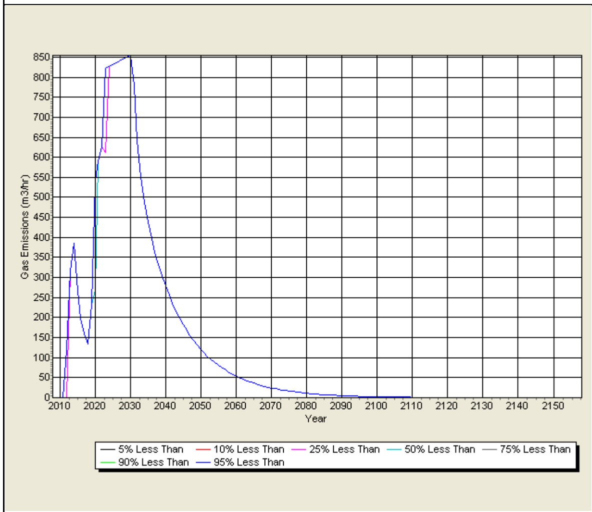
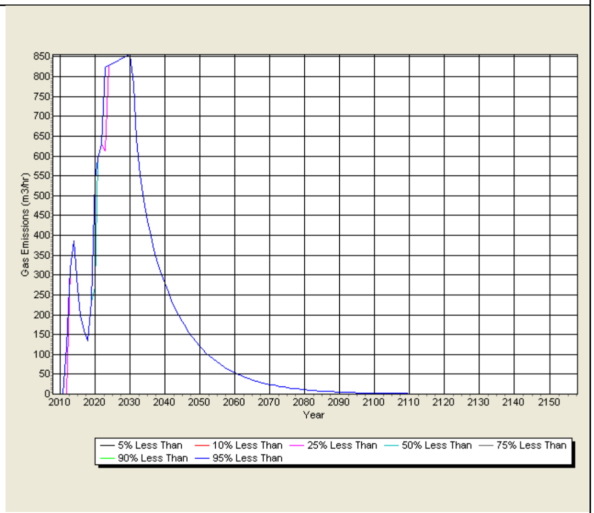


Figure 4. Sensitivity Analysis On Lateral Migration With No Gas Collection System

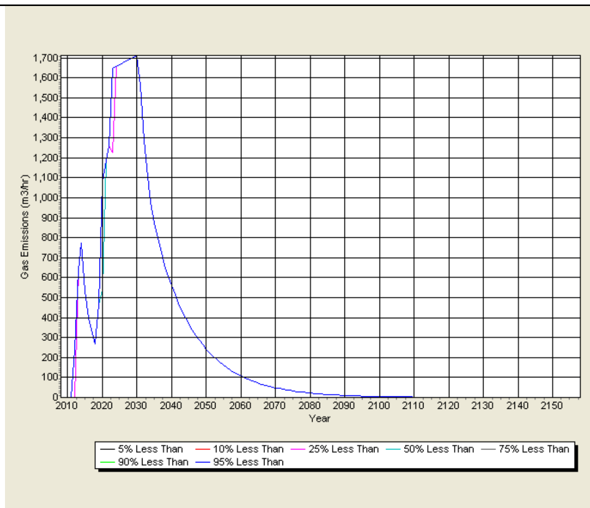
Predicted lateral migration for methane



Predicted lateral migration for carbon dioxide



Predicted lateral migration for landfill gas

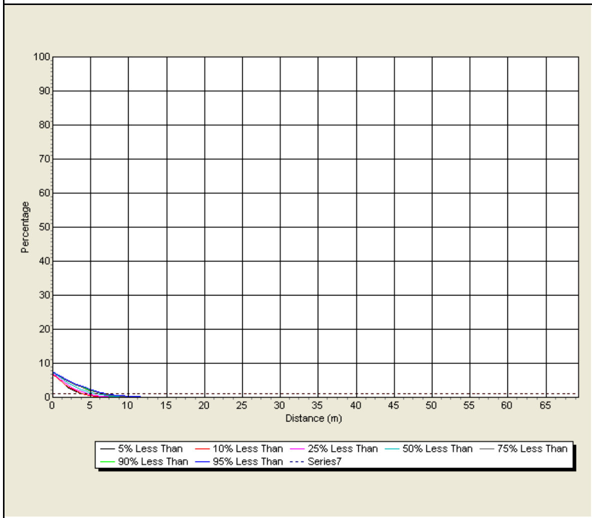


Vegetation Stress - Methane

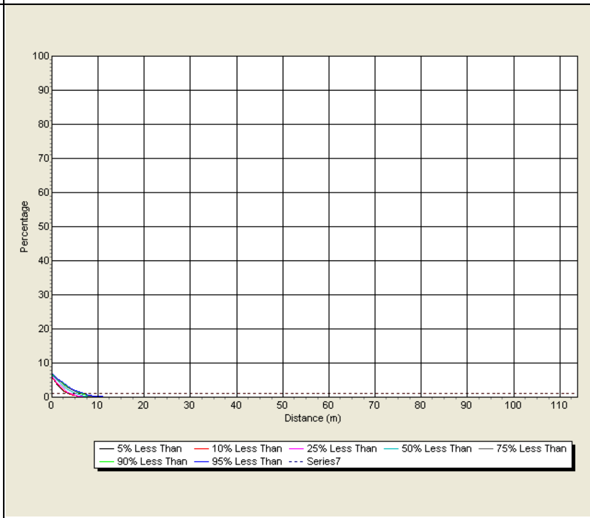
2.5.16 No exceedences of the trigger level of 1% were predicted at the closest receptors for any of the phases. Figure 5 shoes the predicted migration from each phase. The highest concentrations are at the cell boundary reducing to 0% at 10 - 12 metres from the cell boundary.

Figure 5: Methane Lateral Migration For Each Phase Of Newhurst Landfill Site

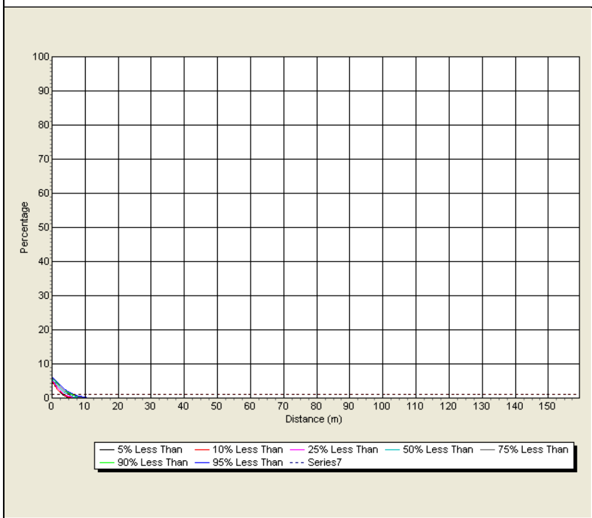
Phase 6



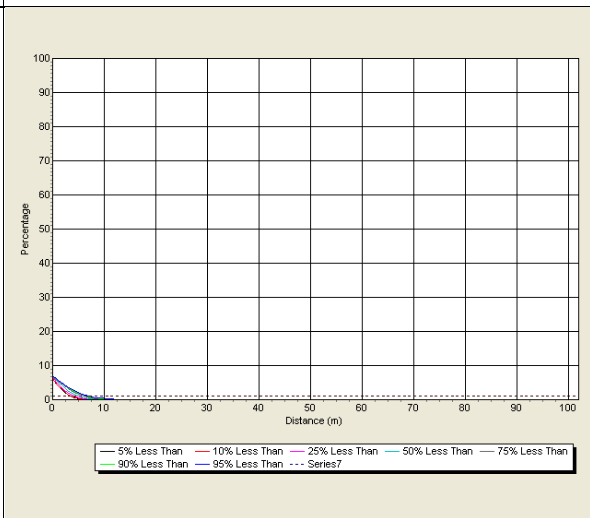
Phase 7



Phase 8



Phase 9

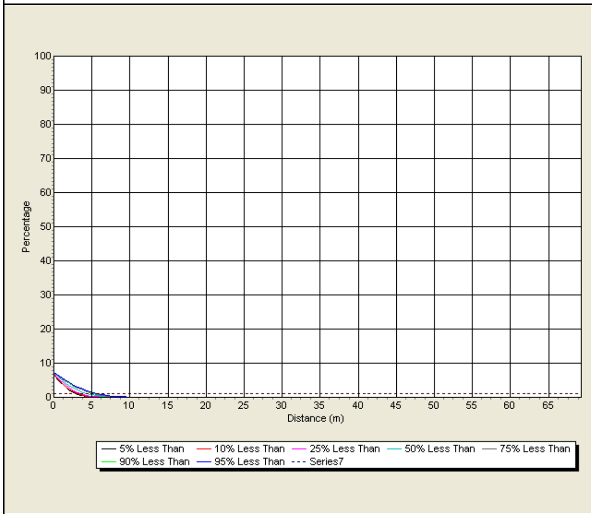


Carbon Dioxide

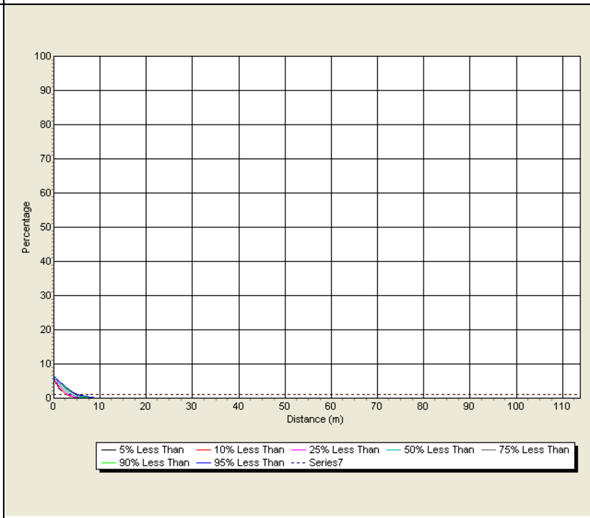
2.5.17 No exceedences of the trigger level of 1.5% were predicted at the closest receptors for any of the phases. Figure 6 has the predicted migration from each phase; the highest concentrations are at the cell boundary reducing to 0% at 8 – 10 metres from the cell boundary.

Figure 6: Carbon Dioxide Lateral Migration For Each Phase Of Newhurst Landfill Site

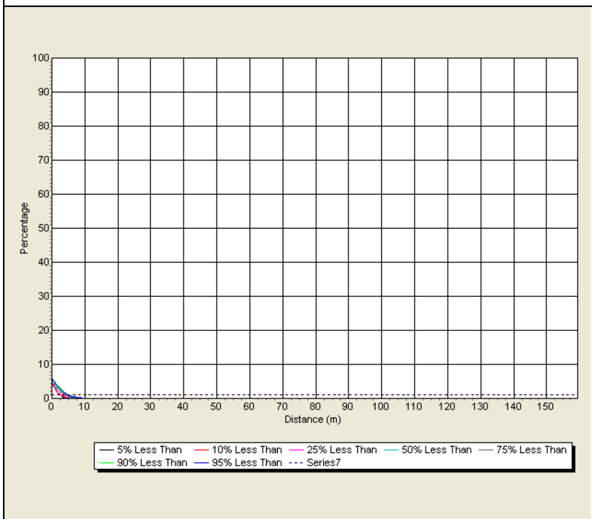
Phase 6



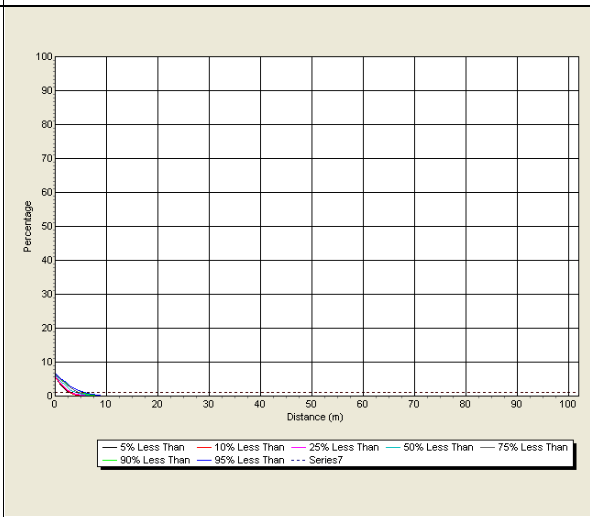
Phase 7



Phase 8



Phase 9

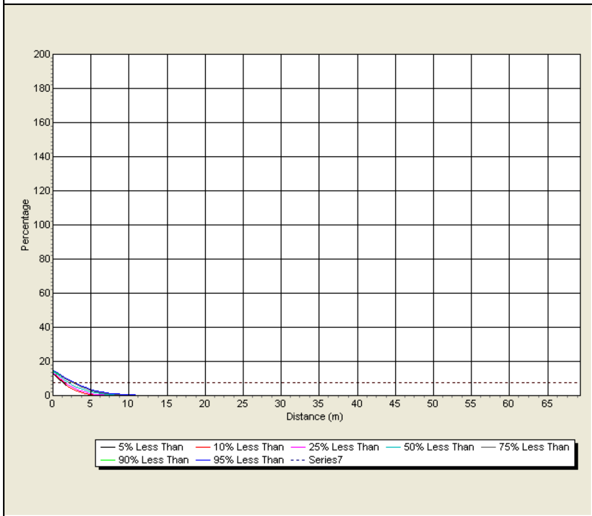


Landfill Gas

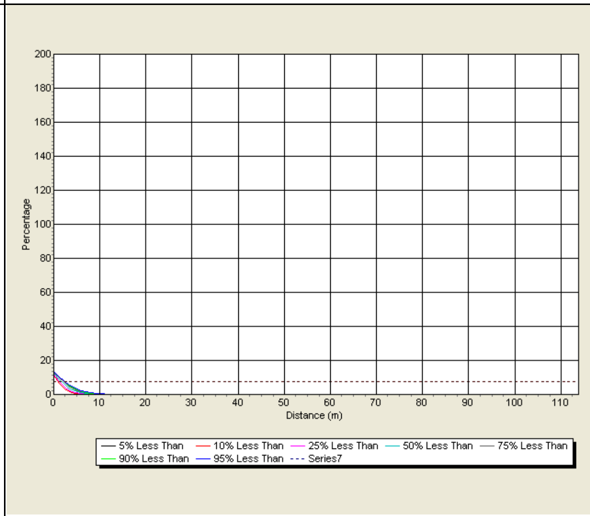
2.5.18 The maximum predicted concentration of landfill gas from GasSim is not likely to exceed the vegetation stress screening level of 7.5%. Figure 7 shows the predicted migration from each phase; the highest concentrations are at the cell boundary reducing to 0% at 9 – 10.5 metres from the cell boundary.

Figure 7: Landfill Gas Migration For Each Phase Of Newhurst Landfill Site

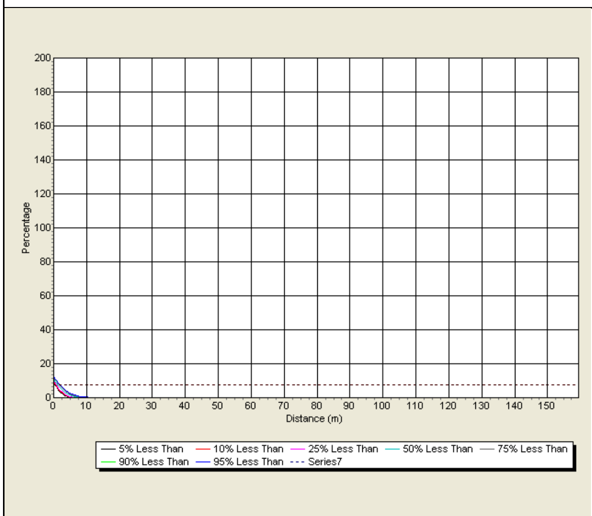
Phase 6



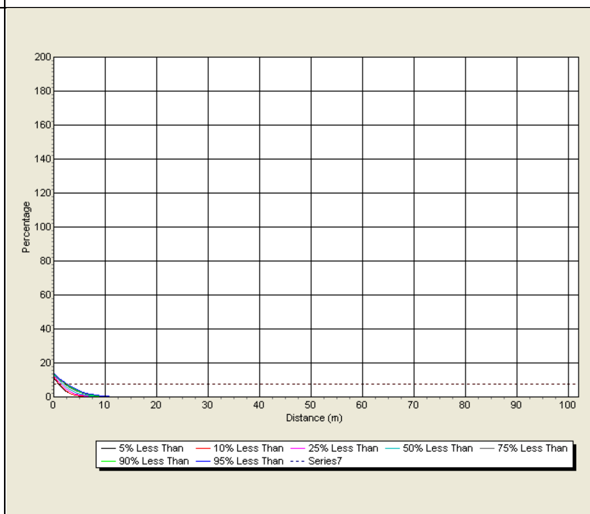
Phase 7



Phase 8



Phase 9



Off-site exposure assessment

2.5.19 A human health risk exposure assessment has been undertaken that considers both direct (inhalation) and indirect (ingestion) exposure pathways. Benzene, Dioxins and Furans, and vinyl chloride have been selected for this assessment as contaminants that have critical exposure criteria and are associated with landfill operation. For residential receptors the recipient is assumed to be a child that is between 0 and 1 years old in 2016 and is exposed for 6 years until 2021 during the highest levels of gas generation from surface emissions. Table 9 has the predicted intake of Dioxins and Furans from Newhurst Landfill site with Table 13 and 14 reporting the predicted values of benzene and vinyl chloride. The results in Table 9 are based on the worst year of emissions from the gas engines in 2033 for the years 2030 – 2035.

Table 9: Predicted Intake Of Dioxins And Furans

Sensitive receptor	Maximum value from 6 years exposure (pq kg^{-1} day^{-1})
No. 2 Ingleberry Rd	59
Fairway Road South	56
Hurst Farm	51
Ingelberry Lodge Farm	54
Ingelberry House Farm	53
Shortcliff Farm	48
Morley Farm	53
Nook Farm	57

[1]Recommended level for ingestion – 2 pg kg-1 day-1

Department for Environment, Food and Rural Affairs and the Environment Agency

2.5.20 As can be seen from the above, the predicted intake of Dioxins and Furans are greater than the recommended daily intake. Therefore, more detailed modelling was undertaken using the new generation dispersion model AERMOD PRIME Version 5.1.5 for Dioxins and Furans using 5 years of meteorological data from East Midlands airport and taking into account the effect of the local terrain and building effects. Emission rates were taken from the GasSim Tier 2 Atmospheric Dispersion module for use in AERMOD PRIME.The results from this modelling are listed in Table 11. As the main contribution of Dioxins and Furans are from the combustion of the gases the maximum year for Dioxin and Furans generation is 2033 and is the year used in the modelling. The location of the gas engines and flares are shown in Table 10. These results predict that the impact from Dioxins and Furans will be lower than that predicted at the nearest receptor.

Table 10: Gas Engine And Flare Specification

	Type	X (m)	Y (m)	Temp. (ºC)	Stack height (m)	Diameter (m)	Emission rate (g/s)
Engine 1	Spark ignition	448786	317794	550	7.5	0.35	0
Engine 2	Spark ignition	448792	317794	550	7.5	0.35	2.3×10^{-09}
Engine 3	Spark ignition	448798	317794	550	7.5	0.35	2.3×10^{-09}
Flare 1	Flare	448809	317800	1000	10	3	0
Flare 2	Flare	448809	317789	1000	8	2	5.8×10^{-11}

Table 11: Maximum Predicted Intake Of Dioxins And Furans From Detailed Modelling At Sensitive Receptors

	Year of meteorological data				
	2001	**2002**	**2003**	**2004**	**2005**
Annual mean (µg/m³)	5.7×10^{-09}	8.0×10^{-09}	7.2×10^{-09}	6.4×10^{-09}	6.9×10^{-09}

2.5.21 The annual mean air concentration results in Table 11 from the detailed modelling assessment when compared to the maximum Tier 1 predictions from the GasSim assessment are significantly lower at the nearest sensitive receptor. The maximum annual mean for the detailed modelling is 8.0 x 10-09 µg/m³ compared to 8.0 x 10-08 µg/m³ predicted by GasSim at the Tier 1 stage in 2033. This difference in results between Tier 1 and detailed modelling can be reflected in the exposure assessment reducing its potential effect by a factor of 10. However, even with the factor of 10 reduction in the potential exposure, the daily intake is still higher than the EA's recommended value of 2 pg kg-1day-1. It should be noted, however, that the reported TDI is based on the TEQ of all Dioxins and Furans. Where consideration is given to the known differences in the toxicity of the different Dioxins and Furans compounds, the identified exposure level is not anticipated to be of potential significance.

2.5.22 Tables 12 and 13 represent the predicted exposure values for benzene and vinyl chloride respectively. There are no predicted exceedences of the ingestion or inhalation levels for either of the pollutants.

Table 12: Predicted Intake Of Benzene

Sensitive receptor	Maximum value from 6 years exposure (mg kg^{-1} day^{-1})
No. 2 Ingleberry Rd	0.00003
Fairway Road South	0.00004
Hurst Farm	0.00001
Ingelberry Lodge Farm	0.00007
Ingelberry House Farm	0.00007
Shortcliff Farm	0.000009
Morley Farm	0.00001
Nook Farm	0.000009

[1]Recommended level for ingestion – 0.29 mg kg-1 day-1, inhalation – 0.91 mg kg-1 day-18 Department for Environment, Food and Rural Affairs and the Environment Agency

Table 13: Predicted Intake Of Vinyl Chloride

Sensitive receptor	Maximum value from 6 years exposure (mg kg^{-1} day^{-1})
No. 2 Ingleberry Rd	0.0006
Fairway Road South	0.0003
Hurst Farm	0.0002
Ingelberry Lodge Farm	0.001
Ingelberry House Farm	0.001
Shortcliff Farm	0.0002
Morley Farm	0.0002
Nook Farm	0.0002

[1]Recommended level for ingestion – 0.14 mg kg-1 day-1, inhalation – 0.3 mg kg-1 day-1 Department for Environment, Food and Rural Affairs and the Environment Agency

2.5.23 A sensitivity analysis was carried out to identify the effect of the failure of the collection systems. Under such circumstances exposure to Dioxins and Furan will be eliminated. However, an increase in the concentration in benzene and vinyl chloride is considered to be likely due to the total increase in surface emission and lateral migration.

2.5.24 It should be noted, however, that the risk to human health from exposure to the trace landfill gases is based on long term exposure and short term increases caused by temporary failures are not anticipated to cause a significant impact on the health of receptors. Without the gas extraction plant the effect at the nearest receptor giving the highest concentration through plant uptake is predicted to increase for both vinyl chloride and benzene by a factor of 1.5 and 1 respectively. None of these increases cause exceedence of the health criteria.

2.5.25 Landfill gas, containing principally methane and carbon dioxide, is a greenhouse gas and therefore contributes to global warming. The UK has made specific obligations under the Kyoto Agreement to reduce emissions of greenhouse gases. The landfill industry's contribution to these aims is significant.

2.5.26 The Global Warming Potential (GWP) of methane is approximately 21 times that of carbon dioxide. Therefore, efficient collection and combustion of landfill gas is required in order to protect the global atmosphere and the environment. The contribution of individual chemicals to the greenhouse effect can be quantified by reference to their relative GWP. This parameter is a function of the radiative properties of the gas and its atmospheric half-life and may be defined as the time integrated change (usually 100 years) in the radiative properties of the atmosphere due to instantaneous release of 1kg of gas relative to that from 1 kg of CO_2. Using the GWPs and quantitative concentration and flux data, the contribution of landfill gas from the landfill to global warming was estimated as part of this risk assessment process.

2.5.27 The Global Impact module of the GasSim model was used to calculate the GWP for the site. The Global Warming Potential (GWP) has been assessed using the default data in GasSim using the 50th percentile. The GWP was determined by summing the emissions of species of interest emitted from the landfill surface. The total GWP for all the relevant gases and of all the years is estimated by the model to be 569,000 expressed as tonnes of carbon dioxide.

Table 14: Predicted Global Atmospheric Impact From Newhurst Landfill Site

Scenario	Year considered	Tonnes of carbon dioxide
Operational period	2019	19,900
Maximum gas generation with gas utilisation	2031	14,500
Sum of all years	-	569,000

2.5.28 Without flares and engines the total GWP of methane for the sum of all years would increase significantly to 783,000 tonnes methane (tonnes of CO_2) compared to 421,000 tonnes methane (tonnes of CO_2) when the engines and flares are in operation, demonstrating the benefit of the flares and engines in reducing methane emissions to the atmosphere.

3 Summary and Conclusions

3.1 Compliance with the Landfill Regulations

3.1.1 An assessment was undertaken to assess the compliance of the site with the requirement of the Landfill Regulation (England and Wales) 2002 and amendments 2004 to identify appropriate measures, where required, to control accumulation and migration of landfill gases.

3.1.2 A conceptual model of the site was built using site-specific data including infiltration rate, meteorological data (from the nearest station), waste tonnage and composition.

3.1.3 Pathways of exposure considered in the assessment included direct atmospheric releases form the land surface, sub-surface migration and direct releases form the engines and flares.

3.1.4 All potential sensitive receptors, as required by the EA, were considered with a number of residential, farm and industrial receptors being identified.

3.1.5 In order to determine the sensitivity of the environment within the vicinity of the site, pertinent environmental benchmarks including the national air quality standards, the Environmental Assessment Levels (EALs) and the Environmental Quality Standards (EQS) were utilised for the assessment as appropriate.

3.1.6 Toxicity, eco-toxicity, potential explosion and asphyxiation are the potential hazards included in this assessment with consideration to emission, air-dispersion and sub-surface migration.

3.1.7 The Environment Agency model, GasSim, was used to undertake this assessment.

3.1.8 The different stages of the landfill's life were considered in order to take into account the effects of any changes that may occur with time.

3.1.9 Potential occurrence of accidents and failure scenarios such as loss of containment, loss of collection and/or treatment capability were considered and discussed or further assessed as appropriate.

3.1.10 The surface and lateral emissions from the site were estimated by the model for key identified landfill gases for a period of 150 years (until the year 2159)

3.1.11 The model identified the need for a gas flaring / utilisation system as the gas generation exceeded the lower flare system capacity of 100 m3/hour. The EA has set the value of 50-100m3/hour of methane flow a simplistic benchmark that can be used to provide an initial indication that flaring or utilisation is required.

3.1.12 The model predicted short-term and long-term emission rates for the key years of gas production and the emissions were compared to their respective environmental assessment levels.

3.1.13 The GasSim results show that the maximum total gas generation is taking place in 2031 and starts to decline in the following years.

3.1.14 The model predicted the surface emission to be significantly lower than the total generated gases due to the gas engines and flares in operation. Gases emitted through the surface are those that are not collected or combusted due to the efficiencies of the collection and engine / flare systems in place.

Tier 1

3.1.15 Tier 1 of GasSim was used to eliminate a large number of landfill gases that were found to be of no significance regarding potential impact on environmental receptors within the vicinity of the site. No gases were found to be significant for the Tier 1 criteria.

Lateral Migration

3.1.16 The maximum lateral migration for methane was predicted to be 7.6% and is reduced to zero at 12.5 metres from the active cell. A value of 7% was predicted for carbon dioxide that reduces to zero at 10 metres from the active cell. There is no predicted impact from lateral migration at the nearest receptors.

Exposure

3.1.17 The predicted intake of Dioxins and Furans are greater than the recommended daily intake and therefore required more detailed modelling using the AERMOD dispersion model. The AERMOD modelling predicted a factor of 10 reduction in the potential exposure, although the daily intake is still higher than the Environment Agency's recommended value of 2 pg kg-1 day-1. It should be noted that the reported TDI is based on the TEQ of all Dioxins and Furans and considering the known differences in the toxicity of the different Dioxins and Furans compounds the identified exposure level is not anticipated to be of potential significance.

Pollution Inventory

3.1.18 The Pollution Inventory results show that all of the modelled gases are below their emission threshold values except for carbon dioxide and methane. It should be noted however, that an active gas collection and flaring system is used on the site when practically possible to reduce methane emission to its lowest possible level. Adequate capping and lining layers are also provided, especially to reduce the general surface emission level of all gases.

3.1.19 It can, therefore, be concluded that based on the current and proposed gas management system the predicted impacts of the different landfill gases emitted from the subject site and dispersed in air are minimal.

References

1. Department for Environment, Food and Rural Affairs and the Environment Agency

Appendices

Appendix A

GasSim model

Appendix B

Predicted Gas Generation

Appendix C

Predicted Lateral Gas Migration

Appendix D

Tier 1 Assessment Results

Appendix E

Newhurst Landfill Phasing