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1.0 INTRODUCTION

WasteServ Malta Limited (WasteServ) prepared this Gas Risk Assessment in support of an application for the development of an interim non-hazardous waste landfill facility at Ta' Zwejra, limits of Maghtab. The proposed facility is located in the vicinity of the closed Maghtab landfill, on the north/east coast of Malta. The proposed development is subject to the IPPC Regulations.

The system of Integrated Pollution Prevention and Control (IPPC) applies an integrated environmental approach to the regulation of waste management activities in operation of the landfill. This means that emissions to air, water (including discharges to sewer) and land, plus a range of other environmental effects, must be considered together. It also means that the WasteServ as the operator must apply such conditions so as to achieve a high level of protection for the environment as a whole. This IPPC application is based on the use of the 'Best Available Techniques' (BAT), which balances the costs to the operator against the benefits to the environment. This application in relation to the Ta' Zwejra IPPC Permit aims to prevent emissions of potential pollutants and where that is not practicable, reduce them to acceptable levels. This application also takes the integrated approach beyond the initial task of permitting, through to the restoration of site when waste management activities cease with proper consideration of specific site conditions around the Maghtab area.

This volume considers the potential impacts on air quality from the construction and operation of the proposed development of Ta' Zwejra Landfill. The assessment identifies existing environmental conditions and receptors that may be affected by the proposed development, potential pollutant releases and the consequences of such releases, and options for mitigation.

The Gas Collection and Extraction system is designed as an extension to the proposed Maghtab Aerial Emission Project (EU funded). Actually it will form an integral part of one centrilised system where the network of vertical gas wells installed within the waste mass of Maghtab, Ta' Zwejra and later of the Ghallis landfill will collect gases generated and direct them to the one Gas Treatment Compound. This Gas Treatment Compound will be designed and sized to serve all current and future needs of all three landfills: uncontrolled Maghtab, interim engineered Ta' Zwejra and 7 years to 20 years waste management facility of Ghallis.

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1.1 Gas Collection and Delivery

The collection of gases and emission will require:

- The installation of gas wells (probably 'impact' wells that do not require drilling) and wellhead access chambers;
- The installation of wellheads onto the gas wells;
- In addition to the wells, steel abstraction pipes may be laid into shallow trenches and covered;
- The installation of steel connecting pipework;
- The installation of manifolds and blockwork chambers;
- The installation of MDPE gas mains (including drainage for condensate);
- The connection of the manifolds to the gas mains;
- The installation of gas mains connecting the manifolds to a gas plant.

1.2 Gas Treatment

Abstracted gasses will be treated in a central compound constructed to treat gases from each site. The plant will comprise:

1. Condensate collection
2. Pumps and regulators
3. High temperature gas flares
4. Noncatalytic oxidation equipment
5. Activated carbon filters for exhaust gases

Long term environmental monitoring will be conducted (partly utilizing some of the instruments installed as part of earlier works). Initially, before commissioning of the systems, this will concentrate on gathering baseline data on air and groundwater quality. Subsequently this information will be used to direct the operations and to assess their performance.

The key environmental media to be monitored are considered to be:

- Aerial emissions associated with the operation of the emissions control system;
- Aerial emissions associated with the earthworks required to install the emissions control system;
- Monitoring of changes in groundwater quality as the emissions control system is implemented.

1.3 On-site Emissions Monitoring

Emissions from the treatment plant will be measured to monitor effectiveness. Records of:

1. particulate matter;
2. volatile organic compounds;
3. sulphur dioxide;
4. nitrogen oxides; and
5. dioxins.

will be undertaken.

1.4 Off-site ambient Air Monitoring

Off-site ambient air monitoring at all three sites will be undertaken. Primarily monitoring will be for total respirable particulates (mass per unit volume). Collated filters containing collected particulate matter will be periodically analysed for the presence of toxic metals in dust. The particulate monitoring semi-volatile organic compounds in air will be collected.

Meteorological data will be collected at all three sites using meteorological stations attached to downwind particulate monitors. The ambient air monitors will be located in secure fenced compounds with a concrete base and either be powered by solar/wind/battery power (if in remote locations) or by mains electricity supply (if located close to services). The ambient air monitors will be capable of storing operational data on-board. Users will be able to access logged information either directly through a user interface or remotely using a modem.

Item
Boreholes with well casing
Galvanised Steel Wellheads
BSP galvanised steel pipe for connecting pipework
Manifolds
Pipe for gas main
Fenced compound
High temperature gas flare
Activated carbon filters
VOC thermal oxidiser
Monitoring/surveying equipment etc.

The results from GasSim modeling used for the same proposed development, originally at different location but latter moved to its current location, was utilised to estimate the amount of gas that may be generated at the site. With GasSim modeling one is also able to predict the airborne concentrations of landfill gas contaminants and combustion contaminants (arising from flaring of gas) at sensitive receptor locations.

2.0 LANDFILL – GENERAL AIR QUALITY ISSUES

Landfill activity has the potential to generate and release substances that can generate an impact on air quality. Releases typically associated with landfill include dust, landfill gas and odour. This section describes general aspects and attributes associated with these releases.

With respect to landfill gas emissions to air there are two main issues:

- Emission of contaminants that may be harmful to health. These contaminants may be contained within the waste itself, generated during decomposition processes within the waste, and/or they may be combustion products generated by; e.g. landfill gas flares.

- Odorous emissions that may be the result of a single contaminant (e.g. hydrogen sulphide) but more generally occur as a result of a complex mixture of contaminants.

Assessment is based on key contaminants that provide an assessment of the potential risk of the landfill and landfill gas emissions. The GasSim model (described later) provides default data on a range of contaminants and has been used to assess potential risk.

2.1 Particulate Matter

Particulate matter covers a range of sizes and types (*e.g.* wind blown dust, sea salt aerosols, biological material and secondary particles). Distribution and effect of particulate matter depends on a wide range of factors including size, shape, density, activity, wind speed, etc. For waste management activities the most common concern regarding dust emissions is nuisance arising from deposited dust.

2.2 Deposited Dust

Nuisance dust is normally perceived as an accumulated deposit on surfaces such as washing, window ledges, paintwork and other light coloured horizontal surfaces, *e.g.* car roofs. When the rate of accumulation is sufficiently rapid to cause noticeable fouling, discoloration or staining (and thus decrease the time between cleaning) then the dust is generally considered to be a nuisance. However, the point at which an individual makes a complaint regarding dust is highly subjective. Occasional clouds of dust can cause a visual and sensory nuisance.

Locations highly sensitive to dust include hospitals, clinics, hi-tech industry, furnishers, painters and food processing. Those moderately sensitive to dust include schools, residential areas and food retailers. Areas of low sensitivity include farms, industry and outdoor storage.

Suspended Particulate

Suspended particulate typically includes particles in a smaller size range of less than 10μg in aerodynamic diameter (PM_{10}) that can be carried long distances by the wind and may be breathed in with the subsequent potential for effects on health. Air quality standards typically refer to PM_{10}. Particles of less than $PM_{2.5}$ are referred to as the fine fraction and are capable of reaching the deepest part of the lung.

Research 19,20,21[a] has established that people with a pre-existing respiratory and/or cardiac condition are more susceptible to health effects from exposure to airborne particles. However, there is no convincing evidence that healthy individuals are normally significantly affected by ambient levels. The UK Government QUARG report states:

'It is unlikely, however, that coarse, wind-blown particles have a significant effect upon health'.

Research at mineral sites in the UK finds that PM_{10} concentrations are similar upwind and downwind22 and concludes that respirable dust is '*barely detectable'* and the possibility of any effect on the health of the local population is *'likely to be remote'*.

Dust Dispersion

Dust is a generic term for particles in the size range of 1-75 microns in diameter. Larger particulate is usually defined as "grit" (BS6069). Particles greater than 30 µm typically deposit within 100 m of the source; intermediate sized particles (10 to 30 µm) may travel up to 200 – 500 m and small particles (less than 10 µm) can travel long distances. Most dusts are deposited within 100m from the source and this is the area where most problems arise.

The generation and transport of releases is dependant on many factors including wind speed and direction, distance to the receptor, particle size, rainfall, topography and substrate. Airborne dust concentrations and dust deposition rates fall off rapidly with distance from the source.

This is primarily due to its dispersion and dilution, but is enhanced by the rapid deposition of the larger particles. The critical wind speed for lifting dust depends on surface conditions and particles size. Lifting of dust into the air, or wind whipping, is typically associated with higher wind speeds of more than $7ms^{-1}$. Rainfall can be sufficient to dampen down and reduce wind whipping by a combination of surface tension and the formation of a crust on drying. Topography effects dust transport as

[a] [19 Quality of Urban Air Review Group (QUARG), 1996. Airborne Particulate Matter in the UK. 3rd Report
20 Committee on the Medical Effects of Air Pollutants (COMEAP), 1995. Health Effects of Non-biological Particles. 21 Department of the Environment, 1995. Expert panel on Air Quality Standards (EPAQS). Particles
22 Opencast Mining, 1996. Dust from Derlwyn: The end in sight?]

heavier particulate tends to fall downward. Dust is variably reduced over higher ground and by the presence of obstacles such as fences, screens, walls, vegetation and trees.

2.5 Landfill Gas

The main components in landfill gas are methane and carbon dioxide with hydrogen, nitrogen and oxygen (Table 13/1). Volatile and semi-volatile organic components are usually present in small quantities (<1% by weight or 0.1to 0.35% by volume) – including alkanes, alkenes, alkynes, aromatic compounds, alcohols, esters, ethers, ketones, carboxylic acids, amines and sulphonated substances. Sulphur containing components have been measured at between 0.9-5.6 $mg.m^{-3}$ and Hydrogen Sulphide (H2S) from <5 to 1416 parts per million (ppm).

Landfill gas may be generated for decades. An idealised representation is shown in the figure below. Rates of generation may be typically 5-10m^3 of landfill gas per tonne of waste per annum. However, emission rates can depend on many other factors such as atmospheric pressure. Gas production rates are commonly estimated as a first order kinetic model for rapid, medium or slow degradability as shown in the box below.

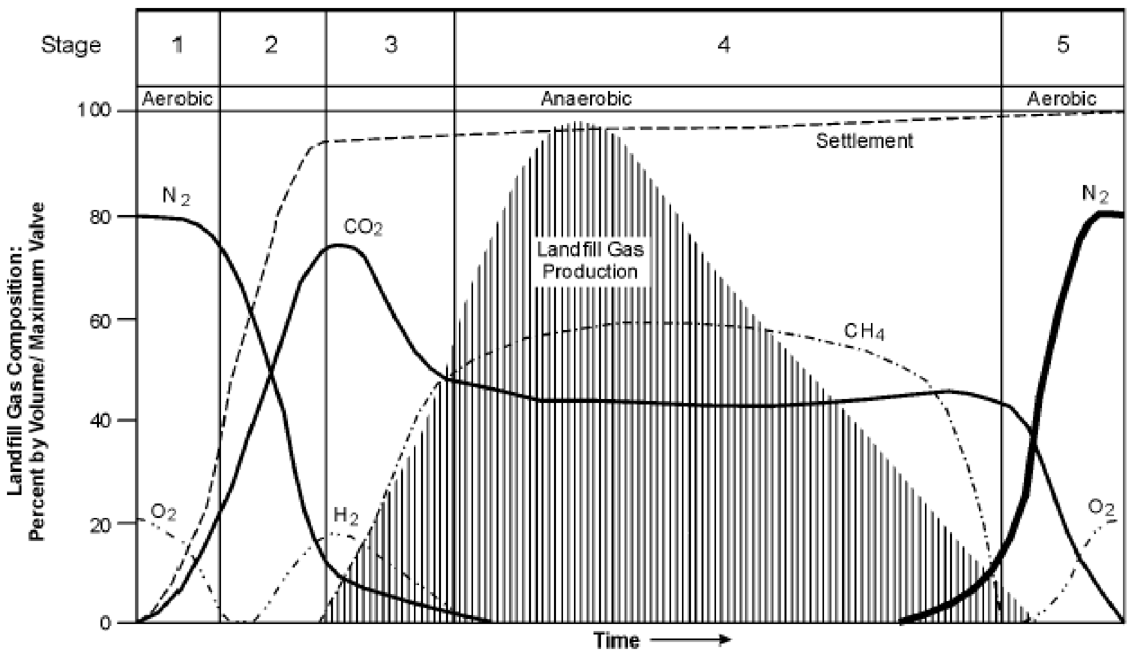
For this assessment, production rates have been calculated using the GasSim model. Surface emission rate (flux) depends on the degree of cover. The UK has established emission rates for various engineering features29 – for example that for a soil cap only is 1mg/m2/s. UK sites have recorded fluxes of:

- with gas control CH4 <0.01->500 $g/m^2/d$ and
- with no gas control CH4 100-1200 $g/m^2/d$.

TABLE 1: **TYPICAL BULK CONSTITUENTS OF LANDFILL GAS**

Component	**Typical Value (% vol.)**	**Observed Maximum (%vol.)**
Methane	64	88
Carbon dioxide	34	89
Carbon monoxide	0.001	0.09
Oxygen	0.2	20.9
Nitrogen	2.4	87
Hydrogen	0.05	21
Water vapour	1.8	4

(Source: Environment Agency)



Idealised Representation of Landfill Gas Generation

Landfill gas is flammable and a potential asphyxiant in enclosed spaces. Trace components of landfill gas do not usually represent a health hazard, though some substances such as hydrogen sulphide (H_2S) can be present in small amounts and H2S is toxic in low concentrations. Sub-surface movement of landfill gas can cause damage to vegetation due to root oxygen displacement. Toxic components in the gas may potentially cause damage to vegetation when released to air – however impacts are not usually significant. The importance of gaseous emissions has been highlighted due to global warming (methane & carbon dioxide emissions) and acid rain (nitrogen & sulphur oxide emission). Methane is approximately 27 times more potent than carbon dioxide in terms of the greenhouse effect and is believed to be responsible for almost 20% of current increases in global warming.

Combustion minimises the greenhouse gas potential of the landfill gas, and destroys organic and potentially odorous compounds. The density of landfill gas is variable; typically ranging from 1.98 kg/m^3 during the early stages to being lighter than air (0.72 Kg/m^3) for a more mature landfill.

Examples of key parameters considered in this assessment are described below.

Benzene

Benzene is a contaminant commonly present within landfill gas and for which there is a statutory European air quality standard. Consequently, predicted concentrations can be compared with standards that have been set for the protection of human health.

Nitrogen Dioxide

Elevated concentrations of nitrogen dioxide (NO_2) are not present within landfill gas but oxides of nitrogen (NOx) are generated during the combustion by landfill gas flares. NOx emitted to atmosphere as a result of combustion consists largely of nitric oxide (NO), a relatively innocuous substance. Once released into the atmosphere, nitric oxide is oxidised to nitrogen dioxide (NO_2), which is of concern with respect to health and as an acidic gas, which may contribute locally to acid rain. As a worst-case it is assumed that NOx emitted from landfill gas flares comprises entirely of NO_2.

Carbon Monoxide

Carbon monoxide (CO) is emitted from landfill gas flares and with NOx is considered to be a potentially significant pollutant with regard to gas combustion impact on local air quality. Carbon monoxide may also be present within landfill gas.

Sulphur Dioxide

Sulphur Dioxide is an acidic gas emitted by the combustion of landfill gas flares and directly from the surface of the landfill. In addition to its adverse impact on human health, sulphur dioxide may be incorporated into water droplets producing sulphuric acid or "acid rain" which causes damage to vegetation and building surfaces. Dry deposition of sulphur dioxide may oxidise to sulphuric acid in the presence of moisture on the surface. When nitrogen dioxide is present with sulphur dioxide, increased corrosion rates can occur.

Hydrogen Sulphide

Hydrogen sulphide (H_2S) is commonly present within landfill gas and has potential impacts on odour nuisance at low concentrations as well as potential human health impacts at higher concentrations. Hydrogen sulphide and other organic sulphides are generated during the decomposition process by sulphate reducing bacteria and may be a particular problem where waste is rich in sulphate.

2.5.1 Landfill Gas Combustion

Emissions from combustion (flaring) of landfill gas can contain compounds derived from an unburnt fraction of the gas; products of combustion; products of incomplete combustion; and contaminants present in the air. UK studies summarise flare emissions to be as shown below. Emission can include potentially corrosive 'acid gases' that are typical of combustion processes. Certain trace compounds when combusted can produce pollutants which have the potential to adversely effect health; such as hydrogen chloride/fluoride, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and dioxins/furans. Enclosed flares generally achieve a much higher level of emissions control. The temperature of a landfill gas flare determines how buoyant the resulting plume is. Exit velocity has a large influence on its physical momentum. High buoyancy and high momentum releases take longer to reach ground and are more diluted. High exit velocities ensure a plume is less affected by the influence of stack tip and building downwash effects. Landfill gas flares discharge vertically at high temperatures (1000° - 1200°C), which keeps the plume aloft for longer and promote effective dispersion of the discharge.

TABLE 2: **TYPICAL ENCLOSED FLARE EMISSION CONCENTRATIONS**

Emission	Concentration
CO_2 %	2.6-14
CO $mg.m^{-3}$	<2-2178
NO_2 mg.m-3	14-149
VOC – Total $mg.m^{-3}$	<2-20
VOC – non methane $mg.m^{-3}$	<0.1-3.9
HCl $mg.m^{-3}$	<5-36
SO_2 $mg.m^{-3}$	30-482

(Source; UK Environment Agency)

2.5.2 Landfill gas dispersion

The generation and transport of releases is dependant on many factors including windspeed and direction, distance to the receptor, buoyancy and atmospheric stability. Downwind receptors will be affected only for that period of the time the wind is blowing from the source. The greater the distance to sensitive receptors, the greater the opportunity there is for a release to be diluted and dispersed. The stability of the atmosphere and wind speeds are important factors in how quickly gaseous pollutants will be dispersed and diluted. An unstable atmosphere can result in peak concentrations closer to the source but rapid dilution downwind. Neutral conditions with high wind speeds promote the rapid dispersion of gaseous pollutants. Under stable atmospheric conditions (which usually only occur at night) and low wind speeds, gaseous pollutants are not as effectively dispersed, particularly when released at ground level.

2.5.3 Odour

Individual response to odour is subjective and varied. Perceived odour intensity usually decreases with:

a) concentration (a non-linear relationship) and
b) time, due to olfactory fatigue or self-adaptation.

Odour may be detectable as a single substance or a mixture and are difficult to measure. Olfactometry uses a trained panel to estimate average dilution to threshold under laboratory conditions – expressing concentration in European odour units (OUE – dilution before an odour is not detected by 50% of the panel). Ambient air contains many odorous substances and may have an odour concentration of between 5-40 OUE m^{-3} 23. The impact of the landfill on odour has been assessed by consideration of total odours and the European odour unit (OUE). The use of the OUE takes into account the odour potential of all substances contained within a mixture.

Significant odour impacts are often characterised by short-term peak concentrations; perhapsfive-second averages. Though an odour may be detected at low concentrations over a long time, it may not constitute a nuisance unless it is detected frequently or is of a particular intensity or type. Generally, odour nuisance complaints do not occur until the concentration at the receptor exceeds the odour detection threshold by a factor of between three and six.

The former Warren Spring Laboratory quoted a typical factor of five 24[b]. However, odour nuisance is also dictated by the offensiveness of the odour – a pleasant odour being less likely to be associated with nuisance than an unpleasant odour of the same intensity, frequency and duration. Therefore an unpleasant odour is more likely to be associated with concentrations of <5OUE. Municipal waste and landfill can generate odorous substances. Odour is generated by the anaerobic breakdown of organic materials, producing organic and sulphurated gases. UK Guidance lists several factors that may contribute to odour problems:

• Handling, treatment & disposal of odorous materials such as sulphur bearing wastes;
• Decomposition of putrescible waste, particularly under anaerobic conditions; giving rise to landfill gas containing H_2S and mercaptans from sulphate reducing bacteria;
• Landfill gas releases from inadequate gas capture arrangements;
• Gas flare systems; flame failure or poor combustion conditions or inadequate dispersion
• Leachate systems; odours from dissolved constituents in the leachate (*e.g.* carboxylic acids and hydrogen sulphide) and from open treatment systems or released by aeration.
• Opening trenches in old waste;

[b] [23 Environment Agency 2002. IPPC H4. Horizontal Guidance for Odour. Part 1 (Draft); 24 Odour Control - A Concise Guide, Warren Spring Laboratory Report (1980); 25 Environment Agency 2002. Interim Guidance for the Regulation of Odour at Waste Management Facilities.]

• Operational failures such as inadequate compaction, too large a working area, wastes not buried quickly enough and inadequate cover
• Excavations into old wastes;
• Use of odour neutralizers;
• Weather conditions;
• Location with respect to receptors.

Important odorants sometimes reported in landfill gas include substances listed below. The presence of several odorants may cause additive effects.

1. hydrogen sulphide;
2. organosulphur compounds (e.g. methanethiol, dimethyl sulphide);
3. carboxylic acids (e.g. butanoic acid);
4. aldehydes (e.g. ethanal); and
5. carbon disulphide.

Under certain meteorological conditions uncontrolled landfill gas emissions can give rise to odours extending kilometres from site. Landfill gas may need to be diluted over a million times in order to render its odour undetectable. The availability of dilution depends on prevailing meteorological conditions and the physical characteristics of the site. Still, calm conditions during cold periods are more likely to give rise to poor dilution.

3.0 LEGISLATION GUIDANCE AND STANDARDS

The proposed development will be subject to the following:

- Planning conditions attached to any planning consent granted by MEPA
- European level legislation on air quality
- National legislation on air quality
- Indicative guidance available in Europe and elsewhere
- A Waste Management Permit issued by MEPA.

The air quality standards and objectives for the primary pollutants associated with landfill activities are summarised in Table 3.

3.1 European & Other Legislation

The ***Framework Directive on Waste (75/442/EEC as amended by Directive 91/156/EEC)*** requires Member States to implement a system of authorisation for waste disposal with conditions to ensure waste is recovered or disposed of without harm to human health or pollution of the environment, including without causing a nuisance through dust or odour.

The ***Framework Directive on Ambient Air Quality Assessment and Management (96/62/EC)*** provides the means for setting limit values, through daughter directives, on the concentrations of air pollutants including dust and odour.

The first and second ***Air Quality Daughter Directives (1999/30/EC & 2000/69/EC)*** set standards and objectives primarily to protect human health. The ***World Health Organisation***'s (WHO) recommended air quality guidelines have been used as a basis for setting EU air quality standards. The WHO's recommendations are not mandatory but are generally accepted as being levels not to be exceeded if healthy air is to be maintained.

Integrated Pollution Prevention and Control (96/61/EC) aims to prevent the pollution of air in addition to water and land) by highly polluting industries which must obtain a permit to operate. Applications for permits must demonstrate that adequate measures are being undertaken to prevent emissions of dust and odours.

3.2 National Legislation

Legal notice 337 of 2001 *Waste Management (Permit and Control) Regulations* require that waste management operations and facilities, including landfills, are covered by authorization from the competent authority.

Legal notice 216 of 2001 ***Ambient Air Quality Assessment and Management Regulations*** require the Competent Authority to establish limit values and alert thresholds for ambient air. Limit values have been set for pollutants including Particulate Matter (PM10) as shown in Table 3. These standards are based on the EU directive standards, except for carbon monoxide, which is based on a WHO guideline.

TABLE 3: AIR QUALITY STANDARDS

Pollutant	Air Quality Standard or Guideline ($\mu g\ m^{-3}$)			
	EU Daughter Directive	WHO[(a)]	Malta	Comment
Sulphur dioxide				Malta from EU Directive 99/30/EC
Hourly mean	350			
Alert Threshold(b)	500	500	500 (175 ppb)	
24-hour mean	125	125	125 (44 ppb)	
Annual mean		50		
Nitrogen dioxide				Malta from EU Directive 99/30/EC
Hourly mean	200	200		
Alert Threshold(b)	400		400 (213 ppb)	
Annual mean	40	40		
Carbon monoxide				Malta from WHO
15-min mean		100 ($mg\ m^{-3}$)		
30-min mean		60 ($mg\ m^{-3}$)		
Hourly mean		30 ($mg\ m^{-3}$)		
8-hour mean	10 ($mg\ m^{-3}$)	10 ($mg\ m^{-3}$)	(9 ppm)	
Ozone				Malta from EU Directive 92/72/EC
Pop Info Threshold			90 ppb (hourly)	
Pop Warning Threshold			180 ppb (hourly)	
Benzene				
Annual mean	5			
URI/lifetime		6×10^{-6}		
Hydrogen Sulphide				
30 min mean		7		Malta standard derived from EU Directive 99/30/EC
Particulate PM_{10} Limit Value 24 hr ave			**50**	Malta standard derived from EU Directive 99/30/EC

(a) Data obtained from 'Guidelines for Air Quality', WHO, Geneva (2000)
(b) Alert Threshold, hourly average value averaged over 3 consecutive hours.
(c) UR refers to Unit Risk and is related to the carcinogenic properties of the pollutant. Value is Tolerable Daily Intake (TDI); I-TEF kg^{-1} bw refers to International toxic equivalent factor per kg of body weight

The Regulations also require measuring stations to be installed and operated to supply data on concentrations and that Action Plans are prepared with strategies for decreasing concentrations. The Regulations require, at an initial stage, to study suspended particulate matter and to consider:

- degree of exposure of sectors of the population, and in particular sensitive sub-groups,
- climatic conditions,
- sensitivity of flora and fauna and their habitats,
- historic heritage exposed to pollutants,
- economic and technical feasibility,
- long-range transmission of pollutants.

Legal notice 168 of 2002 ***Waste Management (Landfill) Regulations*** requires that measures are implemented to minimise nuisances and hazards arising from landfills from the emission of odour and dust. Legal notice 234 of 2002 ***Integrated Pollution Prevention and Control Regulation*** require permits granted to industries including landfills to include emission limits for dust and odours.

3.3 Guidelines

Deposited Dust

Criteria and guidelines have been developed in some countries. For example, the United States and Australia and published criteria range from between 133 to 350 mg m^{-2} day^{-1}. Long term deposited dust criteria have been suggested for urban/semi-rural areas at, typically 200 mg m^{-2} day^{-1}, averaged over a monthly period[c]. The former British Coal Opencast used the figure of 200 mg m^{-2} day^{-1} as a nuisance threshold in the UK. A more stringent guideline of 100 mg m^{-2} day^{-1} has been proposed (as a monthly average) and quoted as likely to provoke complaints at peak periods within that month. The UK Department of the Environment recommends a stand-off distance of 100-200m from significant dust sources (excluding short-term sources), though recognises that these distances can be reduced if effective mitigation measures are identified and implemented.

[c] [26 Williams J, "Fugitive Dust", Mine & Cell, pp 9 –10 (March 1986); 27 British Coal Opencast Northern – Environmental Review (1993); 28 Vallack H W and Shillito D E, Suggested Guidelines for Deposited Dust, Atm. Env., 32 (16) (1998); 29 Environment Agency 2002. Guidance on the management of landfill gas. Consultation; 30 Environment Agency 2002. Guidance for monitoring enclosed landfill gas flares.]

Landfill Gas Combustion

UK guidance is developing for the management of landfill gas - setting out operating standards for landfill gas flaring and gas combustion engines. Guidance provides a tiered approach to the setting of emission limits for landfill gas flares and engines. Emission limits comprise generic emission requirements based on best practice, and stricter, site-specific, risk-based standards where appropriate. Emission standards for landfill gas flares in European countries are shown in Table 4.

TABLE 4: LANDFILL GAS FLARE EMISSION STANDARDS IN EUROPEAN COUNTRIES

Determinand	**Emission standards, mg. m-3 at 3 % O2, dry and 0ºC, 101.3 kPa**					
Country	Germany 96 (proposed)	Germany 2001	Switzerland	Belgium	UK (Existing Plant)	UK (New Plant)
Particulate matter	10		10	5		
Sulphur dioxide			50	35		
Oxides of nitrogen	200	200	80	150	150	150
Carbon monoxide	50	100	50	100	100	50
Hydrogen chloride	10		20			

Odour

Few standards exist owing to the difficulty in defining odour nuisance, measuring odour and assessing compliance with nuisance standards. UK guidance is available on the assessment and regulation of odour from landfill. This guidance indicates that offensiveness is related to the unpleasantness of an odour. The relative offensiveness of landfill odour is ranked as high in draft UK guidance suggesting a criterion for the assessment of acceptability of 1.5 OUE .

3.4 Existing Environmental Conditions

3.4.1 Meteorology

The most important climatological factors in assessing the impact and dispersion of releases:

- **Wind direction** determines the broad transport of the emission as determined by the frequency and duration of wind blowing from the source towards the receptor.

- **Wind speed** increases dust entrainment but also increases initial pollution dilution. The significance of wind speed is different for dust and odour. For dust the proportion of higher wind speeds is important because this enables particles to become airborne. With odour the proportion of low wind speeds and the occurrence of stable atmospheric conditions are more important because this can result in reduced dilution.

- **Atmospheric stability** is a measure of turbulence, particularly of vertical motion. Stability is typified by *Pasquill Stability* categories A (extremely unstable) to F (very stable). Stability D refers to neutral conditions, where mechanically generated turbulence is caused by strong surface winds.

- **Rainfall** can reduce wind whipping by a combination of surface tension and the formation of a crust on drying. Rainfall of as little as 0.2mm in a day can be sufficient to significantly suppress dust.

Drawing ZW 006/04 shows meteorological data for Luqa airport for the five-year period 1995 to 1999. Additional data have also been obtained for the period up to 2001. Luqa is located approximately 10 km to the south-east of the proposed development and approximately 4km from the coast.

Between 1995 to 1999 predominant wind directions were from the west and west-north-west, occurring for 15.5% and 14.4% of the time, respectively. Wind directions from the north, north-east, south-east and south-west sectors occurred relatively infrequently. Calm conditions (i.e. wind speeds of less than 1.5 ms^{-1}) occurred for approximately 16.4% of the time. To 2001 the predominant wind direction was from the west-northwest occurring for 14.5% the time. Wind directions from the west and northwest occurred relatively frequently at 10.2% of the time for each wind direction. Calm conditions (i.e. wind speeds of less than 0.5 ms^{-1}) occurred for approximately 5.5% of the time. Information on frequency of stability conditions and mixing height were not available. The average monthly temperature for Malta is higher than the UK, therefore the mixing heights will generally be higher than those assumed which will aid dispersion of pollutants. Pasquill stability categories F & G generally prevail for less than 7 % of each year.

Mean monthly rainfall, averaged across all the Maltese islands, shows that most rainfall occurs between October and March, with the highest rainfall in December. Some 85% of the total annual rainfall occurs during this six-month period. July is the driest month with drought conditions being recorded 86%. Annual average rainfall is 530mm, however, this is highly variable between years (varying between 1031mm and 191mm). Mean monthly temperature varies from 12.3°C to 26.3°C, the hottest months being July and August, and the coldest being January and February.

Mean maximum and minimum daily temperatures provide a further indication of the variability of the temperatures on the islands. For August this shows that, although the mean monthly temperature is 26.3°C, the mean daily maximum is 30.6°C. Similarly for January, the mean monthly temperature is 12.3°C, but the mean daily minimum is 9.2°C.

3.4.2 Microclimate

Consideration of local factors suggests that there will be differences in site-specific meteorological conditions. Differences would not be likely to be substantial and the use of other data, other than from the representative conditions described above, cannot be justified.

Microclimate is dependent on the regional macroclimate as modified by site-specific conditions. The extent to which local conditions are fairly represented by regional data depends on factors such as distance from the coast, height, topography, etc. For example, stability D is typically the most commonly occurring stability condition inland, whereas coastal locations may be influenced by a strong breeze from the sea during the day and a weaker land breeze at night-time. Coastal locations tend to experience higher wind speeds and less extreme stability conditions (Stabilities A, B, E and F). The distance over which coastal affects take place varies but can be greater than 10km inland.

3.4.3 Topography

Impacts can be significantly affected by terrain height. Elevated terrain reduces the distance between the plume centre line and the ground level, thereby increasing ground level concentrations. Elevated terrain can increase turbulence and plume mixing with the effect of increasing concentrations near to a source and reducing concentrations further away. An elevated discharge location can also experience greater exposure to winds and turbulent mixing, enhancing dispersion and dilution of gaseous pollutants.

The proposed Ta' Zwejra landfill will be located in the north of Malta and is adjacent to the existing closed waste disposal site at Maghtab. The site extends to an area of some 41 000 square meters.

The natural ground surface area slopes gently, with elevations varying from approximately 35 m above sea level to approximately 50 m above sea level close to the old site of Maghtab. The site primarily underlies the Lower Coralline limestone. The site was historically been used for waste management activities with a portion of it consisting of degraded garigue due to the extension of the current landfill Ta' Zwejra 1. The agricultural portion of the site is cultivated during the wet season and remains dormant during the dry (baghli field) season. There are no residential properties within the site, although there are 3 to 4 farmsteads with residences. The nearest area of substantial population is Qawra, which lies some 7km to the north-west and Naxxar, which lies some 5km to the south-west.

Gas releases in the immediate vicinity of the site are likely to be significantly influenced by topography. In general increased surface roughness coupled with coastal propensity for higher windspeed and neutral stability would tend to increase the likelihood for dust entrainment and increase the likelihood of dilution. In addition there would be a tendency for winds to be funnelled NE-SW as described in '*microclimate*' above.

3.4.4 Existing Air Quality

WasteServ as Operator of the proposed development have already begun a regular monitoring program for certain elements of Landfill Gas. Since the beginning of operational life of Ta Zwejra engineered landfill facility there was a regular monitoring of emissions of landfill gases (LFG) contemporary with Maghtab monitoring schedule. With the recent procurement of new equipment, the WasteServ was enabled of observing the following LFG components:

CO_2 – carbon dioxide
CH_4- methane
O_2 - oxygen
CO – carbon monoxide
H_2S – hydrogen sulfide
Temperature and Pressure difference of discharge.

During the Gas Reading recording the basic weather conditions and subjectively measure nuisance impact such as: distribution of odour, litter, dust, noise etc.

Monitoring of the landfill gases at active landfill site of Ta' Zwejra 1 and closed one of Maghtab are being carried out on a regular basis every week. Monitoring points are established taking into the account precaution with respects to hazard to people and property or equipment and for better understanding of processes taking place within the waste masses. One of the best indicators of type of waste degradation is the LFG component breakdown. As the matter of fact we can divide these processes as aerobic and un-aerobic depending on surrounding conditions. Gas composition of mainly CH4, CO2 and H2S will indicate un-aerobic degradation. With the presence of oxygen and aerobic bacteria the LFG will consist of CO_2, N_2, CO, H_2O etc.

Presence of CO in various concentrations generally can give us an idea of rate of exothermic reaction or possible combustion within the wastes. Commonly the following table is used for estimate of aerobic combustion:

TABLE 5: CARBON MONOXIDE CONCENTRATIONS

	CO (ppm)
No fire indication	0-25
Possible fire in area	25-100
Potential smoldering nearby	100-500
Fire or exothermic reaction likely	500-1,000
Fire in area	1,000

At Maghtab there are 11 in number, points from where gas readings are taken on regular basis; the points are indicated on the attached map. The points are distributed over the whole area of closed Maghtab dump and its proximity. Gas readings are also takenin retaining wall chamber between Maghtab and Ta' Zwejra 1 and from the active working surface of Ta' Zwejra 1 engineered landfill. Monitoring is extended till the coast road and inhabited areas of Maghtab village.

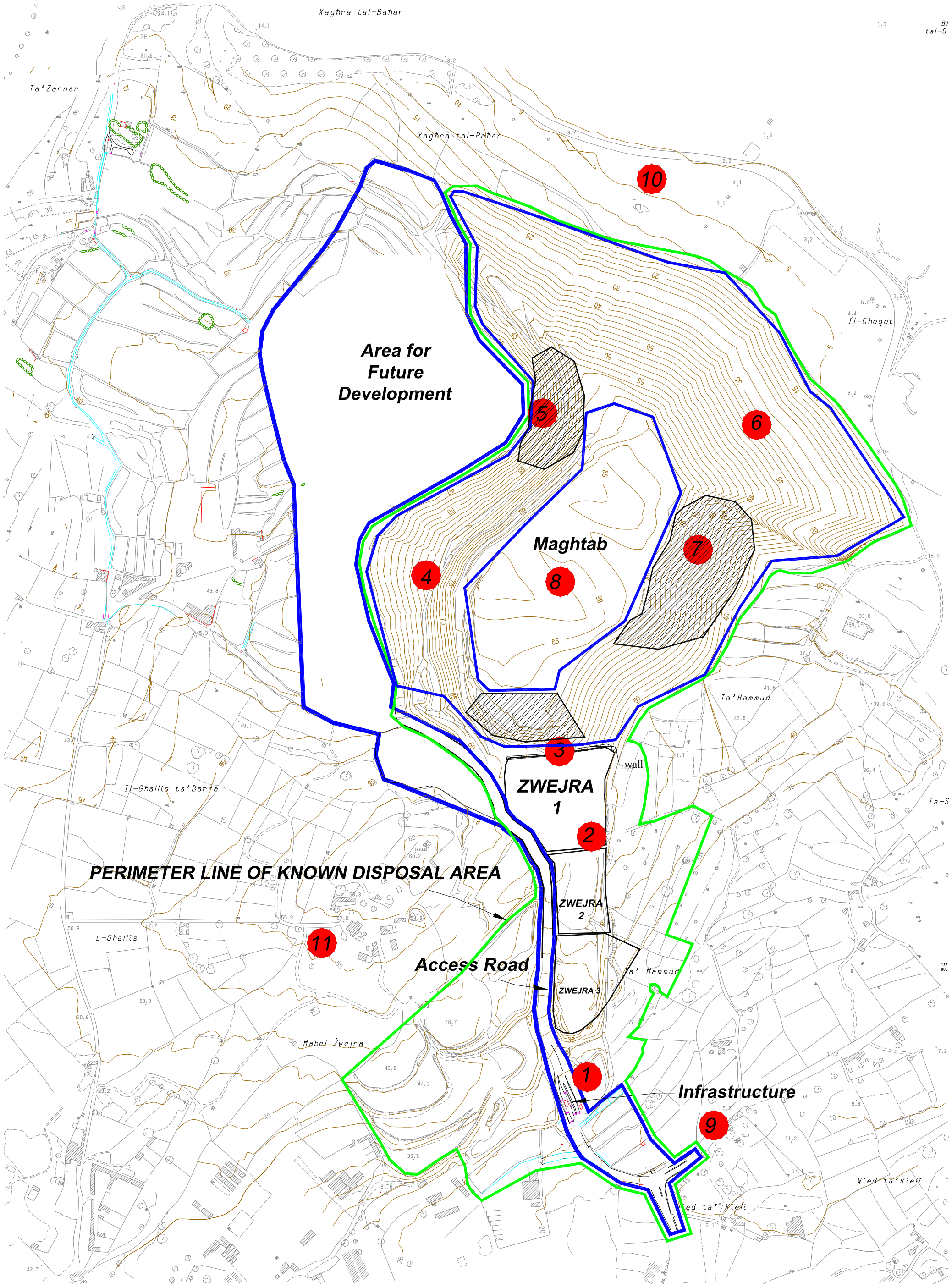
From the results of monitoring it is evident that methane is present in localized pockets of already deposited old waste of Maghtab. Currently the only point where CH_4 was observed is MP7, which is monitoring point situated on the eastern part of Maghtab. Percent is between 4 and 15 % with variations in the composition of LFG due to weather conditions changes. Comparing to the findings of the Scott Wilson 2003 detailed site investigation the rate of production and composition of gases seem to be stable. The significant and sometimes visible amount of LFG is mostly produced on the side slopes which are experiencing air ingression and aerobic type of degradation sometimes becoming exothermal combustion. These areas are shown on the attached map as shaded, and they represent very high temperatures till 180 degrees Celsius.

The top platform of Maghtab (MP 8), which was till the May 2004 receiving just MSW and after then it was covered and compacted seems to be still stable. By visual observations and by gas monitoring schedule we can see that waste is still stable and gas generation rate is still very low. There are no visible cracks and gas neither was nor recorded. We expect that after the coming wet season the degradation will accelerate and gas generation increase. That should coincide with beginning of installation of active gas extraction system.

At present Ta' Zwejra 1 does not yet produce significant amounts of LFG. Due to age of wastes and most important that they are in very dry condition and reasonable well compacted. The active face of the landfill as an environmental impact has more sense as a nuisance. The current hazard from waste management operation is more as a result of dust, litter, rodents, odor and other. The LFG in its real sense is not yet formed but what we experience and senses: gas phase of fresh wastes as a vapors. Here similarly to top of the Maghtab we expect significant gas rate production after the coming wet season. Gases produced are expected to be captured within the contained facility and send for treatment and flaring.

At the moment the current conditions at Maghtab and Ta' Zwejra do not represent any risk due to the fact that the waste body is still very dry and there is not a sufficient amount of oxygen to mix with methane to form an explosive compound but when leaving out to the atmosphere LFG immediately gets diluted to harmless quantities. Particular attention in monitoring of gases is given to the area currently being excavated, where there is permanently presence of equipment and people. Another area of concern is the weight bridge area and inside of the gate building. Within the wall structure we recorded symbolic quantity of methane such as 0.1% which poses no risk. Gas flow and pressure are not sufficient to evacuate LFG to the structures on the site.

It can be concluded that current condition of gasses at Maghtab and Ta' Zwejra at the moment does not present any hazard to the people and property in the vicinity. The constant monitoring which take place every week can give us sufficient time to establish immanent measure to minimize any potential risk. As another control measure frequent inspections to monitor the any possible hazards for employees and clients were introduced.



THE REGULAR GAS MONITORING POINTS

Background concentrations for PM10, NO_2, O_3 and SO_2 have been monitored at many locations in Malta by MEPA, as part of the national air quality assessment program. Data have been obtained for four air quality monitoring stations located within the area. These are shown in Table 6. Data indicate that particulate matter as PM10, measured at various locations and are frequently at levels in excess of the Limit Value of 50µgm^3 per day.

TABLE 6: AIR QUALITY MONITORING RESULTS

Locality	Monitoring Period	Actual days monitored	Parameters Monitored	Exceedance(s)*		
				days	% of days monitored	parameter
Vittoriosa	8-Sep-1999 to 23-Sep-1999	13	SO2, NO2, O3, PM10	3	23	PM10 LV
Siggiewi	1-Oct-1999 to 8-Oct-1999	8	SO2, NO2, O3, PM10	5	63	PM10 LV
Mosta	9-Oct-1999 to 19-Oct-1999	9	SO2, NO2, O3, PM10	3	33	PM10 LV
Fgura	17-Oct-1999 to 25-Oct-1999	6	SO2, NO2, O3, PM10	3	50	PM10 LV
Paola	27-Oct-1999 to 30-Oct-1999	3	SO2, NO2, O3, PM10	2	67	PM10 LV
Zabbar	1-Nov-1999 to 2-Nov-1999	2	SO2, NO2, O3, PM10	2	100	PM10 LV
Qormi	18-Nov-1999 to 26-Nov-1999	9	SO2, NO2, O3, PM10	6	67	PM10 LV
Kalkara	27-Nov-1999 to 9-Dec-1999	12	SO2, NO2, O3, CO, PM10	2	17	PM10 LV
Mellieha	10-Dec-1999 to 20-Dec-1999	11	SO2, NO2, O3, CO, PM10	6	55	PM10 LV
Ghajsielem	1-Jan-2000 to 20-Jan-2000	20	SO2, NO2, O3, CO, PM10	4	20	PM10 LV
Munxar	6-Feb-2000 to 9-Feb-2000	4	SO2, NO2, O3, CO, PM10	0	0	

Mellieha	11-Feb-2000 to 21-Feb-2000	11	SO2, NO2, O3, CO, PM10	0	0	
Qormi	22-Feb-2000 to 2-Mar-2000	9	SO2, NO2, O3, CO, PM10	1	11	PM10 LV
Kalkara	6-Mar-2000 to 10-Mar-2000	5	SO2, NO2, O3, CO, PM10	5	100	PM10 LV
Zabbar	11-Mar-2000 to 20-Mar-2000	9	SO2, NO2, O3, CO, PM10	6	67	PM10 LV
Rabat	15-Apr-2000 to 1-May-2000	17	SO2, NO2, O3, CO, PM10	3	18	PM10 LV
Marsa	2-May-2000 to 20-Aug-2000	50	SO2, NO2, O3, CO, PM10	38	76	PM10 LV
Marsa	2-May-2000 to 20-Aug-2000	50	SO2, NO2, O3, CO, PM10	3	6	SO2 LV
Marsa	2-May-2000 to 20-Aug-2000	50	SO2, NO2, O3, CO, PM10	1	2	SO2 AT
Swieqi	21-Aug-2000 to 7-Sep-2000	15	SO2, NO2, O3, CO, PM10	13	87	PM10 LV
Dingli	8-Sep-2000 to 28-Sep-2000	19	SO2, NO2, O3, CO, PM10	4	21	PM10 LV
San Gwann	16-May-2001 to 25-May-2001	9	SO2, NO2, O3	0	0	
Floriana	26-May-2001 to 3-Jun-2001	8	SO2, NO2, O3, CO	0	0	
Birzebbuga	4-Jun-2001 to 8-Jun-2001	5	SO2, NO2, O3, CO	0	0	
Sliema	28-Jun-2001 to 5-Jul-2001	6	SO2,NO2,O3,CO	0	0	
Valletta	15-Sep-2001 to 2-Oct-2001	18	SO2,NO2,O3,CO,PM10	3	17	PM10LV

Rabat	5-Oct-2001 to 15-Oct-2001	11	SO2,NO2,O3,CO,PM10	6	55	PM10LV
Marsa	15-Oct-2001 to 9-Nov-2001	25	SO2, NO2, 03, CO, PM10	17	68	PM10LV
Luqa	23-Nov-2001 to 5-Dec-2001	13	SO2, NO2, O3, CO, PM10	3	23	PM10LV
Zurrieq	7-Dec-2001 to 7-Jan-2002	32	SO2, NO2, O3, CO, PM10	3	9	PM10LV
M'Xlokk	7-Jan-2002 to 15-Jan-2002	9	SO2, NO2, O3,CO, PM10	2	22	PM10LV
Naxxar	22-Feb-2002 to 1-Mar-2002	8	SO2, NO2, O3, CO, PM10	2	25	PM10 LV

* occurrence when air quality standards were exceeded

AIR QUALITY STANDARDS			
Parameter		Standard	Reference
SO_2	L)imit V)alue	44ppb (24hr average)	EU Directive 99/30/EC
	A)lert T)hreshold	175ppb (hourly average over 3 consecutive hours)	
NO_2	A)lert T)hreshold	213ppb (hourly average over 3 consecutive hours)	EU Directive 99/30/EC
O_3	P)op. I)nfo. T)hreshold	90ppb (hourly average)	EU Directive 92/72/EEC
	P)op. W)arn. T)hreshold	180ppb (hourly average)	
CO	G)uideline V)alue	9ppm (8 hourly average)	WHO
PM10	L)imit V)alue	50µg/m^3 (24 hour average)	EU Directive 99/30/EC

Parameter	**Description**
SO_2	Sulphur Dioxide
NO_2	Nitrogen Dioxide
O_3	Ozone
CO	Carbon Monoxide
PM10	Particulate Matter (less than 10µm)

No data on deposited dust levels are available within the vicinity of the site or for Malta as a whole. In northern, Europe deposited dust in rural areas is typically in the order of 39 mg m^{-2} day^{-1} as an annual median[d]. With a nearby specific source of dust emissions (for example power stations) rates are of the order of 59 mg m^{-2} day^{-1} as an annual median. Recent data indicate the following typical deposition rates (expressed as monthly means):

- 30 – 80 mg m^{-2} day^{-1} for urban locations; and
- 10 – 50 mg m^{-2} day^{-1} for rural locations

There are no measurements of odour concentrations available around the proposed development site. Local sources of potential odour include agricultural activity and the farming industry in the vicinity of site.

RECEPTORS IN THE VICINITY OF THE PROPOSED DEVELOPMENT

Potentially sensitive receptors within 500m are shown in drawing ZW 001/04. There are no locations with a high sensitivity, including hospitals or clinics, hi-tech industries, painting and furnishing or food processing within 500m. There is small settlement of Maghtab village in closed proximity. Other settlements are Naxxar, 7 km to the south, and Qawra, 5 km to the north-east. Buildings within 500m include residential property and buildings used for occasional agricultural, industrial or hunting purposes.

[d] [31 Warren Spring Laboratory (WSL), The Investigation of Atmospheric Pollution – Deposit Gauge and Lead Dioxide Observations, October 1965 – March 1982 Inclusive; 32 Parret P W, Dust Emissions – A Review, Computational Mechanics Publications (1992).]

4.0 SOURCES OF RELEASES FROM PROPOSED DEVELOPMENT

4.1 Dust and Mitigation Measures

The amount of dust generated by each activity depends on particles size, density and moisture content. Dust emissions are greatest when there is a plentiful supply of small dry particles. The principal activities that would give rise to potential for dust emissions from the proposed development have been identified as follows.

4.2 Site Preparation

Site preparation includes construction of the access road and ramps into the excavated voids. The road would be surfaced to limit dust emission. Construction would take 2-4 weeks. During this time the potential for dust generation would be high. Dust would be derived from locally derived rocks – essentially inert and the same material as naturally generated dusts. Within the excavated voids there is minimal requirement for excavation being limited to the formation of leachate collection basin to provide a stable and engineered void. The excavated areas would be prepared and graded using mechanical equipment. Typically, excavated material would be placed directly to the area to be graded – i.e. there would be minimal transport of stone.

Preparation of the Cells 2 and 3 may take 12-16 weeks. During this period there is the potential for high dust emission from excavation, tipping and grading. This would tend to be limited by being within the excavated void and primarily comprise inert particulate.

The generation of dust can be mitigated through good site management practices. As soon as possible materials would be graded, packed and stabilised or provided with an outer layer of larger stone to prevent dust release. If appropriate, areas would be encouraged to vegetate. There is already established a regular practice of providing water for dust suppression all around the landfill site.

Mineral Extraction Operations

There would be no commercial extraction of mineral. All extraction is expected to be performed at a financial cost to the developer

Landfill operations

Waste would be delivered to the site by a variety of vehicles; via a surfaced access road to the weighbridge area and then over internal roads to the working face. Imported waste would be
tipped in the active cell and spread and compacted by a landfill compactor. A bulldozer would operate within the active cell spreading temporary cover material. This material forms a thin layer over tipped and compacted waste and helps to stop wind blown dust and litter and minimises the release of odours.

The inherent moisture and bagged nature of some waste types aids reduction of dust emissions as would the application of daily cover material. The moisture content of municipal waste can vary considerably depending upon the constituent make-up, but typical levels of between 10% and 80 % have been published. Dusts would be derived from non-hazardous or inert materials. They would comprise a mixture of locally derived inert fines from the spreading of cover materials and organic and other particulate derived from the spreading and disturbance of non-hazardous waste. The greater proportion of waste is likely to be from the disturbance of surface cover materials. It is likely that dust derived from non-hazardous waste would be low.

Haulage on Site

The main source of potential dust emission would be the movement of trucks across the site. The weight of vehicles, their speed, the number of wheels in contact with the ground and the prevalent weather conditions affect the generation of fugitive dust.

During the site preparation stages there would be no requirement to transfer material between cells or to move it over significant distances within the cell void. Therefore potentially high emissions would be infrequent and short term. Landfilling and restoration of each cell void would be associated with vehicle movement on unsurfaced roads for a total of approximately 3-4 years. In the utilities and facilities area dust may be generated from surfaces and become entrained and distributed by the passage of vehicles and wind-blow.

The potential for dust releases would be minimised by the imposition of vehicle speed limits and by maintaining the condition of temporary (unsealed) roads. In addition the locally occurring rocks and soil used to grade the haul roads readily pack to form a hard and stable surface; effectively limiting the potential for dust emission. In the utilities and facilities area, access roads and yards would be surfaced or packed hardstanding. This would reduce the potential for dust emission compared to un-surfaced roads. Roadways and yard areas would be maintained and kept well packed by rolling or similar and kept free of loose materials.

Sources of Landfill Gas & Odour and Mitigation Measures

Waste would not normally be stored but taken directly by the delivery vehicle to the void. Waste would be immediately tipped and covered within the day as described previously. This would initiate the control of landfill gas and minimise odour release.

Landfill Gas

Landfill gas is the end product of the decomposition of biodegradable wastes in a landfill site. Landfill gas is typically up to 65% methane and up to 35% carbon dioxide and includes organic gases and vapours; some of which may be malodorous, potentially harmful to health and may produce corrosive compounds on combustion.

Methane and carbon dioxide are used to indicate the presence of landfill gas. Landfill cells would be constructed and operated to minimise the release of landfill gas. Progressive capping and restoration of disposal cells would be undertaken and a landfill gas collection system installed to capture gas for treatment. Collected gas would be treated by combustion using a landfill gas flare situated in the environmental management compound serving for rehabilitation of Maghtab and Ta' Zwejra gas collection. There would be no passive venting as such of landfill gas from the site. The collection and combustion of landfill gas would be designed and implemented in accordance with guidance on the management of landfill gas29. This represents best available technique for landfill gas management.

Gas Generation Estimates

Landfill gas generation has been estimated using the model GasSim. The GasSim model contains default information for a wide range of gases that typically are emitted from landfill sites and landfill gas treatment plant. The Ta' Zwejra Waste Cells have been modelled separately using the following assumptions of average waste moisture content (default value).

GasSim Model Assumptions:

1. Ta' Zwejra Cell: commences 2004, infilled in 3 phases @ 370,000 tpa to a capacity of 500,000 cubic metres.

2. Waste composition: 50% Household, 30% Commercial/Industrial and 20% Inert.

3. Lining and capping with all gas wells installed at completion of tipping.

For an 'average' moisture content, the combined peak gas production occurring in 2005 is approx 1,075 m^3/hr LFG. Assuming an 80% gas collection efficiency this suggests a peak collection volume of 860m^3/hr. For a 'dry' site, the combined peak production in 2006 is approx 550m^3/hr, which with an 80% gas collection efficiency suggests a peak collection volume of 440m^3/hr. The difference in the gas production profile is quite striking.

The total volume of gas produced is the same, but the peaks are different and the time period is much longer for the dry waste. This will be important in selecting flare size – if waste is dry the size of the flare required will be smaller than for a site of 'average' moisture content, but it will need to run for a longer period. Gas treatment compound will be sized and designed as for modular extensions to accommodate progress in landfill constructions.

5.0 SCREENING IMPACT ASSESSMENT

5.1. Dust Impacts Screening

A screening exercise has been undertaken to identify sites and conditions where impacts cannot be ruled as being likely to be so small as to be considered as trivial. Receptors up to 200m from operations may be at risk of being affected by dust. For the purposes of assessment a distance of up to 300m is considered beyond which impacts are considered likely to be trivial and not considered further. Winds blowing towards a receptor for less than 2% of the time are used as a guide to assess cases where effects may be likely to be trivial and not considered further. In some cases however, lesser frequencies may still be significant and are not ruled out for further consideration.

Airborne dust generation increases with wind speed. A wind rose showing the frequency of winds at speeds of greater than 5 ms^{-1} is presented below. Wind speeds of above 5 ms^{-1} occur for approximately 35% of the time. Wind directions from the west and north-west occur most frequently with frequencies of 7.1% and 6.2%, respectively.

Quantitative prediction of dust impacts is difficult, principally because dust emissions depend upon several factors, many of which are site specific and vary daily. The focus of attention in dust assessments is usually on the measures to prevent or minimise the dust emissions. Emissions from all source areas would not be continuous. The table below indicates that from the proposed site development the moderate winds would occur from between 0.8-3.84% of the time at nearest housing and the farms.

Considering the wind blow towards housing and the farms for less than 2% of the time and may therefore be considered likely to be insignificant. At over 250m from the site the farms would in any case be unlikely to be significantly affected by dust deposition. Winds would blow towards the coastal area for more than 5% of time. The coastal area is a large area and winds would blow to any one point for a small part of the time - therefore effects may also be considered to be likely to be insignificant.

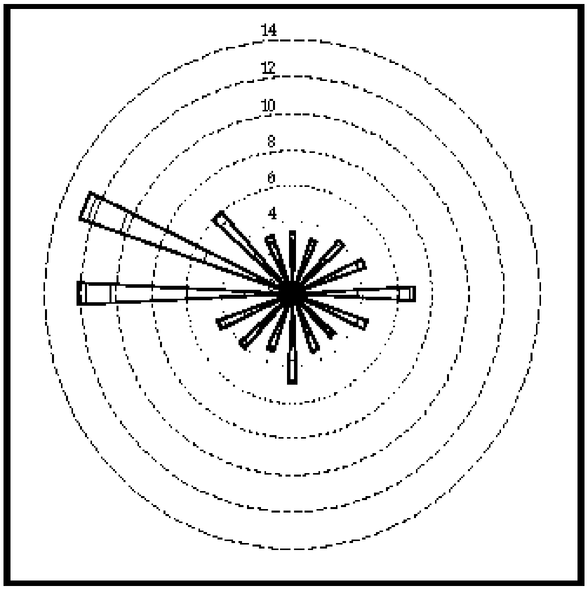
Considering the site properties it can initially be screened out as not likely to be affected by winds blowing from the operations area. However at distances of more than 250m it is likely that dust impacts would not be significant.

Regarding the residential properties to the west they would receive a greater quantity of inert material that would be likely to generate high levels of dust. Much of this would be contained within the cell void and in addition the properties are elevated by some 20m above the operations area and would benefit from dust being contained or tending to deposit out more quickly before reaching the property. However, due to being near the coast and the presence of the valley directing winds towards the coast, there would be no tendency for the local topography and coastal effects to increase windblown towards the property.

With respect to potential impacts on health; with PM10 levels already being high activities would not be likely to substantially increase measured PM10 levels and impacts would be relatively short term. Therefore the overall effects on health would be ***low to negligible.***

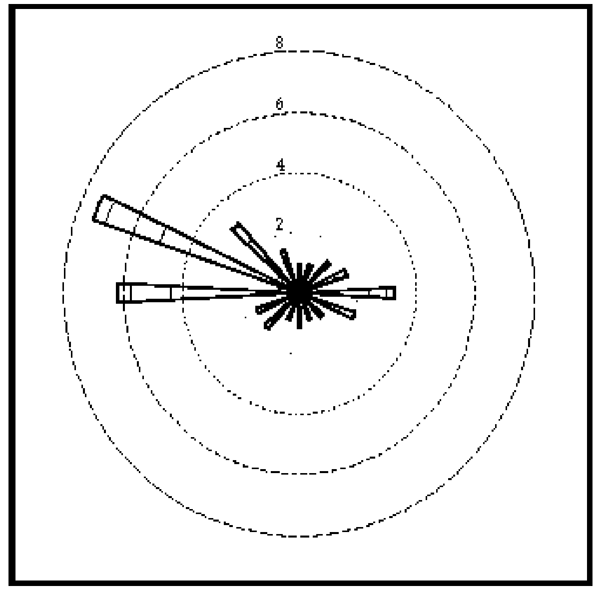
At less than 100m at the closest point to operations and just below the level of the site, the coastal road may be at risk from dust deposition. Being inert the dust would not be harmful and should be detectable over no more than short-term timescales. Effects would therefore be harmless and temporary. It is considered that the overall effect of dust on the coastal road would be low. At other receptors including the properties in vicinity of site the effects of dust would be ***negligible***. At the occasionally used farm buildings the overall effect of dust is likely to be no greater then low.

WINDROSE FOR LUQA, MALTA



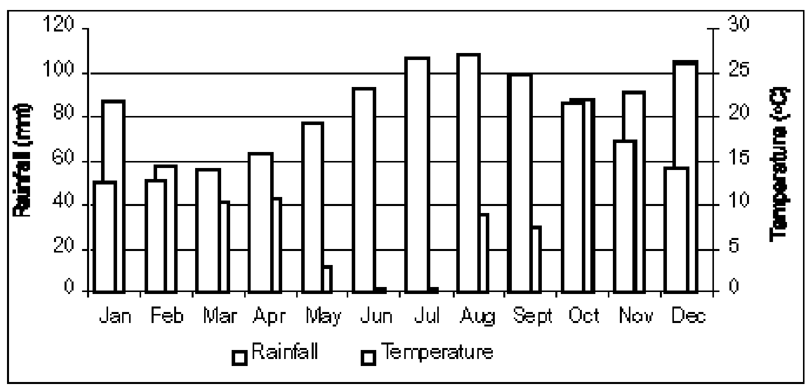
The segments of each arm represent the five wind speed classes, from the centre outwards the classes are 1.5 to 3.1 m/s, 3.1 to 5.1 m/s, 5.1 to 8.2 m/s, 8.2 to 10.8 m/s and >10.8 m/s

FREQUENCY OF WIND DIRECTIONS FOR MODE RATE WIND SPEED CONDITIONS AT LUQA



The segments of each arm represent the three wind speed classes, from the centre outwards the classes are 5.1 to 8.2 m/s, 8.2 to 10.8 m/s and >10.8 m/s.

MEAN MONTHLY RAINFALL [1] AND TEMPERATURE[2] FOR MALTA



1.0 Rainfall figures are based on data obtained from the Water Works Department (1854 – 1950) and the Luqa Meteorological Office (1951 – 1986).
2.0 Temperatures are based on data from the Luqa Meteorological Office (1951 – 1986).

5.2 Landfill Gas and Odour Impact Screening

Landfill gas is dispersed by the wind under all conditions. However, odour nuisance from a ground level source is most likely to occur under stable conditions and low wind speeds. A wind rose showing the frequency of all winds and low wind speeds (<3 m s-1) likely to exacerbate odour nuisance problems is presented in Drawing 13/2. These conditions occur for 39% of the time and the predominant wind direction under these conditions is from the west-south-west to west-north-west sector at 3.3% 6.2% and 3.7% respectively.

The Landfill Gas Monitoring Report suggests that at all receptors the frequency of exposure to landfill gas and odour is not likely to be severe being between 3-8% of the time for most receptors. However, initial screening suggests that impacts cannot screened out at residential property as likely to be trivial and therefore further assessment has been undertaken. However, the potential influence of odour from the nearby farms and agricultural areas is considered to be significant and therefore difficult to distinguish between them further. Because of the difficulties in assessing potential emissions from different sources of the proposed development both with and without treatment and comparing this with criteria for health and environmental protection, the decision was taken to use the predictive estimation tool GasSim.

6.0 IMPACT ASSESSMENT - LANDFILL GAS SIMULATION MODELLING

6.1. Model Description - GasSim

GasSim is a landfill gas risk assessment tool that has been developed by the UK Environment Agency to evaluate the environmental performance of different gas management systems and to optimize landfill gas management. Technical details about the model can be obtained from the agency website www.environment-agency.gov.uk

GasSim combines modules dealing with gas generation, migration, impact and exposure into a single integrated model. The Monte Carlo simulation technique is used to model the uncertainty associated with input parameters. GasSim uses a multi-phase first-order decay equation to determine the generation of methane, carbon dioxide and hydrogen produced from the waste mass, composition and moisture content. GasSim can be used to address:-

- health effects from trace gas emissions and combustion products by assessing several exposure scenarios, each of which has a set of defined exposure pathways and exposure factors for the critical groups;
- the local environment from odour and vegetation stress;
- the global atmosphere through global warming and ozone depletion.

The GasSim model contains default information for a wide range of gases that typically are emitted from landfill sites, either from the landfill surface or from landfill gas utilization plant. GasSim does not have facility to model coastal effects and complex terrain. This should be borne in mind in considering the results of the dispersion modeling study.

Modeling Approach and Philosophy

The results from modeling of same development at different proposed location with the complex topography required the risk assessment modeling in a "complex" fashion, using GasSim (Version 1.02) to provide an indication of the potential risks. The 95% percentile (%ile) confidence level has been used, unless otherwise stated. The 95%ile presents a low probability of occurrence and is commonly considered to be a reasonable assessment level.

6.2 Model Inputs and Assumptions

Parameters used are appropriate for design and operation of the site. Where there is no site specific information, the GasSim default values have been used. Where there is uncertainty concerning the parameter to be used, probability density functions (PDFs) have[e] been used to provide an appropriate range for the parameter. Details relating to the parameters used are discussed below.

Infiltration and Landfill Characteristics

The input value for the infiltration coefficient has been assumed as Normal (50, 5) mm a-1 as
10% (with a standard deviation of 1%) of the average precipitation estimated for the site location. Waste moisture content has not been calculated has not been used in modeling.

Ta’ Zwejra Landfill, Cells 1-3

The capacity of the Three Cells is around 500,000 m^3. The landfill geometry assumed for the three cells are as follows:

- Landfill length (north-south) approx. 170 m;
- Landfill length (east-west) average 80 m;
- Area of landfill 41,000 m2.

6.3 Source

To assess a worst case situation it has been assumed the site will accept approximately 370,000 tones of waste per annum. Waste disposal will commence in the Cell No 1 which on the basis of this infill rate will have a lifetime of around 8 months. Waste disposal at the Cell No 2 is predicted to occur for just over three months. Landfill gas is likely to be generated after minimum of one year due to dry conditions would be collected via an abstraction system and directed to a high temperature flare. The system will be installed on completion of infilling.

The landfill gas flare would be positioned in appropriate location of the environmental compound to serve in the same time for destruction of gases from Maghtab closed landfill and Ta’ Zwejra three cells with possibility to modular extension for Ghallis landfill needs. The waste breakdown assumed for the site is given in Table 7 below. Waste

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[e] [33 As defined by the Environment Agency, November 2002, Draft Guidance on the Management of Landfill Gas. Complex assessments should be carried out in a quantitative manner using stochastic techniques; They should be carried out when the site setting is sufficiently sensitive to warrant detailed assessment and a high level of confidence needs to be provided.]

compositions assumed are the GasSim defaults for domestic and commercial waste derived from national household waste and industrial waste survey programmes.

TABLE 7: WASTE BREAKDOWN FOR PROPOSED LANDFILL

Waste Type	(%)
Domestic	60
Commercial	20
Industrial	20

Methane and Carbon Dioxide Concentrations

Typical concentrations of methane and carbon dioxide present in landfill gas are assumed.

- Carbon dioxide (%) Single (40); and
- Methane (%) Single (60).

Cellulose Decay Rates

The GasSim default cellulose decay rates for average moisture conditions have been assumed for this assessment and are as follows:

- Slow cellulose decay rate of 0.046;
- Moderate cellulose decay rate of 0.076 and
- Fast cellulose decay rate of 0.116.

6.4 Trace Gases

Worst case default values for trace gas concentration have been used except for hydrogen sulphide. For hydrogen sulphide default values were based on a site that experienced significant hydrogen sulphide emissions; due to calcium sulphate waste at the landfill. Consequently, the modeling has used a more realistic range based on monitoring within raw gas. Trace gas concentration data used for hydrogen sulphide is as follows:

- For hydrogen sulphide – LogTriangular(0.0029, 10, 1000) mgm^{-3},
- The GasSim (Version 1.02) default is LogTriangular(0.00057, 2.4, 5570) mgm^{-3}

6.5 Gas Flare

It is assumed that a 1000 m^3hr^{-1} flare will be required as detailed in Table 8. The operational period for the flare has been estimated from the predicted gas generation at the site. A typical landfill gas collection efficiency of 80% has been assumed. The actual capacity and design of flare will be obtained from tendering and contracting conditions of Maghtab Aerial Emission Control Project (EU funded).

TABLE 8: LANDFILL GAS FLARE

Flare/Engine	Operational Period	Capacity (Nm3 h-1)
Flare	**2005 to 2030**	**200 to 1000**

Trace gas emissions of CO and NOx from landfill flare are presented in Table 9 below. The UK Environment Agency's draft guidance on emissions limits for flares have been used and represent the standard for proposed limits. The upper value is derived by multiplying the limit by 1.5 to provide a worst case assessment.

TABLE 9: CARBON MONOXIDE AND NITROGEN OXIDES FROM GAS FLARES

Gas Plant	Carbon Monoxide (mg Nm^{-3})	Nitrogen Oxides (as NO_2) (mg Nm^{-3})
Agency draft guidance for flares (a)	LogUniform(100,150)	LogUniform(150,225)
(a) Draft Guidance for Monitoring of Enclosed Landfill Gas Flares (December 2002) with higher values representing 1.5 times the standard.		

Meteorological Parameters

Meteorological data are described in Section 5.1. Assumed values for stability conditions and mixing height are presented in Table 10.

TABLE 10: METEOROLOGICAL PARAMETERS USED WITHIN GASSIM

Wind Vector (a)		*Frequency of Wind Vector*	
0		7.4%	
30		5.4%	
60		6.4%	
90		9.3%	
120		5.9%	
150		5.3%	
180		7.2%	
210		6.0%	
240		7.9%	
270		20.3%	
300		14.3%	
330		6.4%	
	Frequency	*Wind Speed*	*Mixing Layer Depth*
Stability A	0.75%	1.0 m s^{-1}	1,300 m
Stability B	5.7%	2.0 m s^{-1}	900 m
Stability C	16.3%	5.0 m s^{-1}	850 m
Stability D	62.4%	5.0 m s^{-1}	800 m
Stability E	6.7%	3.0 m s^{-1}	400 m
Stability F	8.4%	1.5 m s^{-1}	100 m

(a) GasSim requires wind data to be input as wind vectors (*i.e.* the direction to which the wind is blowing)

Landfill Gas Emissions

Assuming waste disposal begins in early 2004, maximum predicted values can be summarised as follows (as the 50%ile):

- Landfill gas generation – 1,075 m^3hr^{-1} in 2007
- Flare output – 825 m^3hr^{-1} in 2007
- Surface emissions from the three cells – 50 m^3hr^{-1} in 2007

Beyond 2030, landfill gas collection is predicted to be less than 200 m^3hr^{-1}. The minimum gas usage of the proposed flares is 200m^3hr^{-1} and it may be necessary to consider the operation of the flare on a non-continuous basis in order to optimise gas collection and flaring and minimise release into the environment at this time.

Predicted Off-site Impacts – Air Quality

The impact on local air quality of the following has been assessed:

- Oxides of nitrogen as nitrogen dioxide (NO_2);
- Carbon monoxide (CO);
- Hydrogen sulphide (H_2S);
- Benzene; and

- Oxides of Sulphur as sulphur dioxide (SO_2).

Oxides of nitrogen and carbon monoxide provide an indication of the impact on air quality of the landfill gas flare whereas; hydrogen sulphide and benzene provide an indication of the impact on air quality of surface emissions.

For contaminants emitted from the Landfill Gas Plant (NO_2 and CO), concentrations have been predicted using the distance from the flare. For the other contaminants that are more likely to be emitted from the surface of the landfill, concentrations have been predicted using the distance from the centre of each site and adding the individual predicted concentrations for each receptor together.

Predicted 95th percentile of the annual average concentration for 2007 (the year of peak gas generation) is presented in Table 11. ***Predicted concentrations for all contaminants are within the appropriate air quality standard or guideline value***.

TABLE 11: PREDICTED 95%ile ANNUAL AVERAGE CONCENTRATIONS (2007)

	NO_x (as NO_2) ($\mu g\ m^{-3}$)	**CO ($mg\ m^{-3}$)**	**H_2S ($\mu g\ m^{-3}$)**	**Benzene ($\mu g\ m^{-3}$)**	**SO_x (as SO_2) ($\mu g\ m^{-3}$)**
	0.41	0.00029	0.050	0.055	0.69
	0.33	0.00024	0.0059	0.0010	1.0
	0.27	0.00019	0.0043	0.00077	0.40
	0.15	0.00011	0.011	0.00055	0.31
	0.21	0.00015	0.0028	0.00030	0.49
	0.11	0.000075	0.0024	0.00034	0.26
	0.47	0.00034	0.0087	0.0011	1.4
Guideline value	**40 (a)**	**10 (b)**	**7 (c)**	**5 (d)**	**50 (e)**

(a) Annual average air quality objective for NO_2 to be achieved by 31 December 2005
(b) Maximum eight hour air quality objective for CO, annual mean predictions should be substantially less than the maximum eight hour standard
(c) WHO 30 minute guideline concentration for substantial odour nuisance, predicted concentrations as the annual mean should be substantially less that this value
(d) UK annual mean air quality objective for benzene to be achieved by 31 December 2010
(e) WHO annual mean guideline concentration

Relative to their air quality standards, highest concentrations occur for NO2; where maximum predicted concentrations are 0.47 μgm^{-3} (1.2% of the air quality standard for NO_2). NOx emitted from the gas flare will comprise nitric oxide (NO) a relatively innocuous contaminant and nitrogen dioxide (NO_2). The assessment assumes that all of the NOx is emitted as NO_2 and, as such, is a worst case assumption as only 20% of the NOx is likely to comprise of NO_2 at the receptor locations considered. Assuming 20% NO_2, the maximum predicted concentration of NO_2 would be 0.094 μgm^{-3} (only 0.24% of the air quality standard for NO_2).

For all contaminants considered, the assessment of atmospheric dispersion of contaminants on off-site receptors indicates that ***the proposed landfill would have negligible impact on human health*** (from direct inhalation).

Predicted Off-site Impacts – Odour

For ground level sources such as the landfill site, odour nuisance is more likely to occur during stable conditions (Stability F). Predicted odour concentrations are below the assessment criteria of 1 OUE m^{-3} at all sensitive receptor locations. The highest predicted 95%ile odour concentration occurs at 0.11 OUE m^{-3}. This concentration represents 11% of the assessment criteria. This suggests that ***odour from the landfill is unlikely to be detected and would be of such a low intensity that it is unlikely to cause an odour nuisance***.

Predicted Impact on Properties within 200m

Dry deposition rate is governed by deposition velocity, which is dependent on species, nature of the surface and on atmospheric conditions. Dry deposition velocities for grassland (which will not differ significantly from deposition velocities to stone) of SO_2 and NO_2 are around 12±3 mms^{-1} and 1.1 to 2.4 mms^{-1} respectively. Therefore, for the purposes of this assessment the following worst-case deposition velocities have been assumed;

- SO_2 – 15 mm s^{-1}
- NO_2 – 2.5 mm s^{-1}

Removal of gaseous species from the atmosphere also occurs via wet deposition, where the gas particles are scavenged by cloud or rain droplets and deposited during rainfall events. Wet deposition of gaseous species depends on the solubility of the gas in the raindrops and the rainfall rate. A conservative upper limit for the wet scavenging coefficient of reactive gases is 3.4 x 10-6 s^{-1} for a 0.06 mm hr^{-1} average rainfall rate. The predicted dry and wet deposition of SO_2 and NO_2 is presented in Table 12.

TABLE 12: PREDICTED DEPOSITION RATES (2007)

Sulphur Dioxide		Nitrogen Dioxide	
Dry Deposition (μg m^{-2} s^{-1})	Wet Deposition (μg m^{-2} s^{-1})	Dry Deposition (μg m^{-2} s^{-1})	Wet Deposition (μg m^{-2} s^{-1})
0.0049	5.42×10^{-11}	0.00068	3.06×10^{-11}
0.0026	1.47×10^{-11}	0.00036	8.21×10^{-12}
0.013	3.94×10^{-10}	0.0019	2.25×10^{-10}

Whilst no data are available to assess the potential for these deposition rates to impact on stone these are generally less than 1% of long term values for the protection of health and a fraction of ambient background measured values. It is therefore concluded that ***the potential for impact on the properties and agricultural features including the marine environment will be negligible***.

7.0 PROPOSED MITIGATION MEASURES

The following techniques will be in place in order to prevent or minimise the generation and release of emissions or to control emission to acceptable levels so that releases and impacts are controlled to acceptable levels. These techniques reflect Best Practice in Europe.

7.1 Dust

(a) During site preparation mechanical equipment shall be operated so that materials are placed and not dropped from a significant height. Use of high velocity equipment will be minimised or equipment shall be fitted with local air extraction and filters.

(b) Prepared surfaces shall be stabilized as soon as practicable by covering with loose stone or inert material. This shall include graded surfaces within the cell void or at the edge of the cell.

(c) The access road shall be surfaced up to the weighbridge and environmental area.

(d) Temporary surfaces and haul roads shall be hard packed by means of roller or similar. From observation the local material readily packs to provide relatively dust-free hard-standing and haul roads.

(e) Materials handling shall be minimised. It is not required to move preparation materials significant distances within the cell. These shall be put directly in place and stabilized as described above.

(f) Deposited waste shall be compacted immediately and if appropriate given a temporary cover with other compacted waste material. As soon as practicable and at least by the end of the same day, waste shall be given a temporary cover.

(g) Vehicle movement will be restricted to the prepared temporary haul roads.

(h) Vehicle speed shall be restricted to 10 mph on unsurfaced haul roads.

(i) Hard surfaces shall be swept/scraped so as to remove potentially dusty materials.

(j) It would not normally be practicable to provide water for dust suppression.

(k) Dust generated within the void would tend to be contained by the cell wall.

(l) Mechanical plant used on site would have upward facing exhausts where practicable so as to prevent dust generation.

(m) Vehicle cleaning equipment would be installed at the exit to each cell void and used by all HGVs leaving the site.

(n) Site management would continuously monitor operations likely to cause the generation of dust within the site boundary. Significant events including prevailing weather conditions would be recorded.

7.2 Waste Management and Odour Control

(a) Waste shall not be stored but immediately taken to the tip face for disposal.

(b) The size of the tipping area shall be restricted;

- Deposited waste shall be compacted immediately and if appropriate temporarily covered. As soon as practicable and at least by the end of the same day, waste shall be given a cover of inert fill material.
- Malodorous waste shall be buried immediately.
- Tipping shall be planned so that there is no requirement for subsequent re-excavation or handling of waste materials.

(c) Except in the early life of the voids there would be no passive venting of gas.

(d) Landfill voids would progressively capped and restored. These shall be capped with a sealed lining material of the highest specification so as to contain landfill gas and odour.

Landfill Gas Capture and Treatment

(a) A landfill gas capture system shall be installed including sealed landfill gas wells and chambers connected to headers and Pipework. Landfill gas shall be treated by combustion. The gas capture system would be connected to the gas treatment system on completion of infilling of each area.

(b) An enclosed landfill gas flare shall be provided with the capacity to provide treatment for over 80% of the landfill gas produced. The flare specification shall be to the highest appropriate standard available to comply with treatment needs. This shall remain for the effective lifetime of bulk landfill gas emissions. The specification for the flare shall be determined in consultation with the planning and waste authorities. The collection and combustion of landfill gas would be designed and implemented in accordance with guidance on the management of landfill gas29 and represents best available technique for landfill gas management.

Prior to final selection of the enclosed flare, detailed estimates of gas generation rate and treatment options shall be undertaken. The flare will comply standards for gas treatment and emissions control such as those defined by industry best practice standards as developed by the UK Environment Agency (see previous descriptions in this section).

A typical specification for the flare shall be that it shall operate in the range of 200-1000m^3. It will be fully enclosed or shrouded as such flares achieve a much higher level of emission control. The enclosed flare shall be designed so as to permit an homogenous temperature distribution across the combustion chamber; it shall be lined with refractory material on the interior; contain the flame within it (ie not be a visible flame); and be maintained in effective condition. Dimensions cannot be precisely estimated at this stage but shall typically be 0.75 m in diameter and 3–5 m in height.

The flare shall be located within the environmental control area so as to maximise potential dispersion and minimise potential health and environmental effects. The flare shall be accompanied by all the appropriate support equipment including:

- condensate knock out pot; dewatering filter;
- gas booster; flame arresters; automatic temperature control; flame sensors;
- electronic ignition; sampling points; Combustion air shall be controlled so as to achieve a 1,000 °C temperature (950-1050°C) and 0.3 seconds retention time [above 1200 °C NOx formation increases].
-

Corrected emission concentration shall generally comply with the best emission standards as described in Table 4 including:- CO 50 mg/Nm^3, NOx 150 mg/Nm^3, unburned hydrocarbon 10 mg/Nm^3.

The minimum methane concentration for combustion at specified temperature shall be 25%. At lower CH_4 concentrations temperature turndowns shall be expected.

8.0 GENERAL RECOMMENDATIONS

In addition to the foregoing, the following measures would be adopted as an integral part of the operation of the waste management facility:

a) Where practicable waste arriving at the site would be contained within enclosed vehicles or vehicles would be sheeted to minimise dust blow and deposition of waste and litter onto the haul roads.
b) In order to demonstrate its willingness to deal with any possible problems, Wasteserv would establish a complaints response system with a contact name and telephone number. This would enable the public to call if a dust or odour incident occurs and for appropriate action to be taken on-site to reduce emissions.

9.0 CONCLUSIONS

An assessment has been carried out of the potential impact of activities on air quality. Activities covered by this assessment include site preparation and construction, waste management operations, traffic, landfill gas generation and odour. Potential impacts include the effect of dust and landfill gas on health and as nuisance dust and odour.

Potentially sensitive receptors include residential property, agricultural sensitivity and nearby marine environment. Information is presented on meteorological conditions and the potential for local topography to affect the local climate is assessed. Existing air quality and contributions and effects of existing pollution sources are considered.

Appropriate air quality standards and objectives (both as ambient and emission standards) are identified to provide information for comparative evaluation: including national standards for Malta, WHO and other EU criteria.

Preliminary screening has identified cases and conditions where impacts would be likely to be trivial. Options that could not be dismissed as trivial or are so sensitive so as to warrant further study have been identified for more detailed assessment. Screening assessment rules out the potential for significant dust nuisance to arise, except at the nearest property.

The UK Environment Agency approved landfill gas model, GasSim, is used to predict the quantity of landfill gas likely to be generated. Peak emission rates are associated with average moisture conditions. Modelling has been carried out for average moisture conditions representing a worst case for the site. The model predicts that there would be sufficient gas generated at the landfill site to operate a 1000 m^3hr^{-1} flare.

Dispersion modelling using meteorological data from Luqa Airport has been carried out to assess the impact of surface emissions of landfill gas and emissions from the landfill gas flare on the concentration of contaminants at sensitive receptors. Predicted concentrations are compared to the air quality standards and objectives and assess the potential for impact on health, odour and the environment.

In summary this assessment establishes:

- Dust impacts would be limited to potential nuisance in the immediate vicinity of the site boundary. Health impacts of dust emissions would be likely to be low to negligible.

- At the nearest residential property, interrupted significant nuisance dust from construction/operation at the cell no. 3 would have the potential to be moderate to high with the potential to be considered high for short periods of time. This could occur intermittently for a 3-4 months period.

- At all other receptors dust impacts would be likely to be low to negligible.

- To minimise the potential for dust nuisance strict measures should be put in place to prevent and control dust.

- For emissions to air the maximum predicted concentrations for all contaminant emissions are well within the appropriate air quality standard or guideline value.

- The proposed landfill would have negligible impact on human health (from direct inhalation).

- Odour from the landfill is likely to be detected only within the site perimeters and would be of such a low intensity that it is unlikely to cause an odour nuisance for external receptors.

- The potential for impact on the agricultural features including the coastal and marine environment will be negligible and in any case could not be detected.

- Mitigating measures are recommended so as to minimise and control potential emissions. These include a range of measures to for dust and odour suppression.

- The landfill will be capped and sealed and provided with active gas capture and gas treatment system. These shall be to the best available industry standard as described by regulatory guidance for control.