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Booth Ventures Waste (Midlands) Ltd

Report No. 5430-BLP-R-007-02
August 2023

Sandown Quarry Landfill

Environmental Permit Application – Gas Risk Assessment (GRA)

BOOTH VENTURES

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1 Introduction

1.1 Report Context

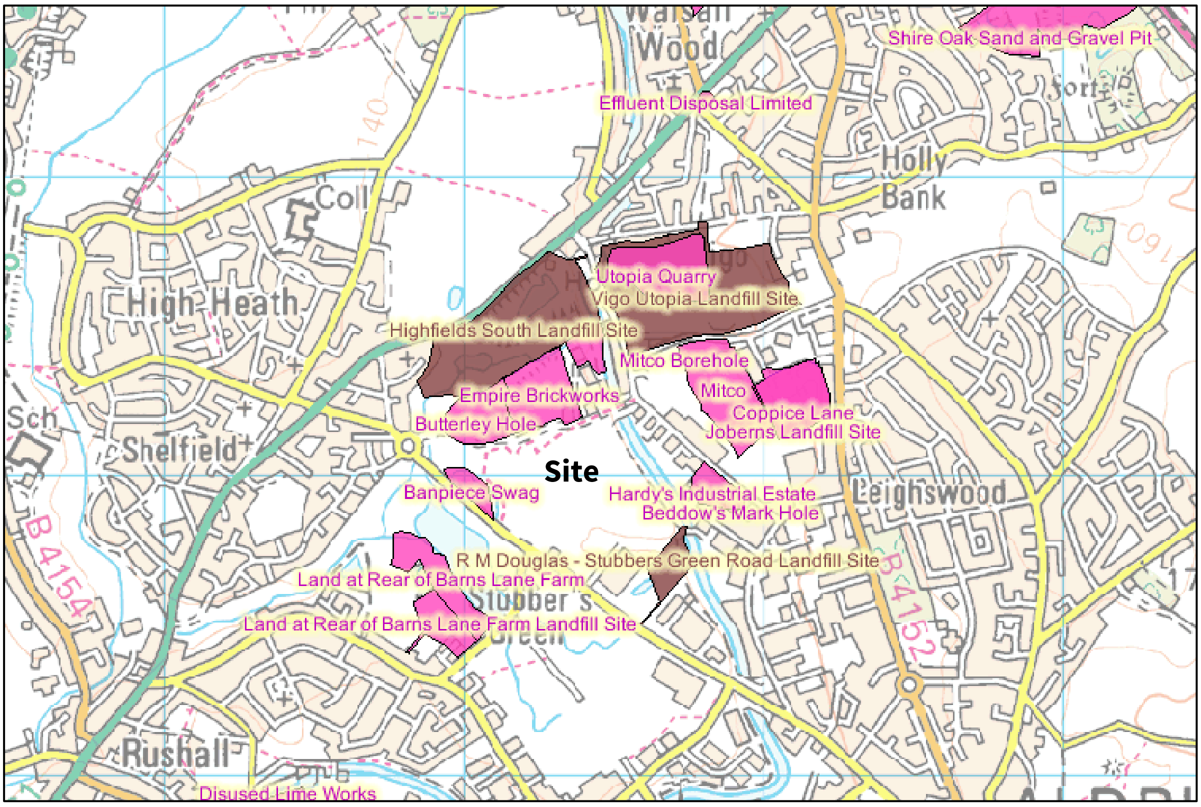
The purpose of this report is to provide a qualitative landfill gas generation / risk assessment (LFGRA) for the Sandown Quarry Landfill Site. The permit application proposes to allow for disposal of inert and non-hazardous wastes within an excavation of the Etruria Formation.

The application facilitates the restoration of the site to allow for the import of wastes suitable for quarry restoration. HM Revenue and Customs (HMRC) made specific allowance for quarry restoration identifying a very limited list of suitable wastes in accordance with The Landfill Tax (Qualifying Material) Order 2011 (as amended). It is proposed to accept wastes consisting of excavation, construction and demolition wastes and potentially some similar industrial wastes that are inert or have a low level of contamination.

Under the requirements of the Landfill Directive, landfill gas must be collected from all landfills receiving biodegradable waste. The gas must be treated and if possible, used. The Directive also requires that landfill gas that cannot be used to produce energy must be flared.

The biodegradable Butterley Hole / Empire Brickworks Landfill Sites are located directly to the north of the site, no gas risk assessments are available for review for these sites. There are numerous landfill sites within 500m of Sandown Quarry (Figure 1). Only Sandown Quarry Landfill (the proposed site) will be considered as part of this landfill gas risk assessment (LFGRA).

Figure 1 Site Context and location of nearby Landfill Sites

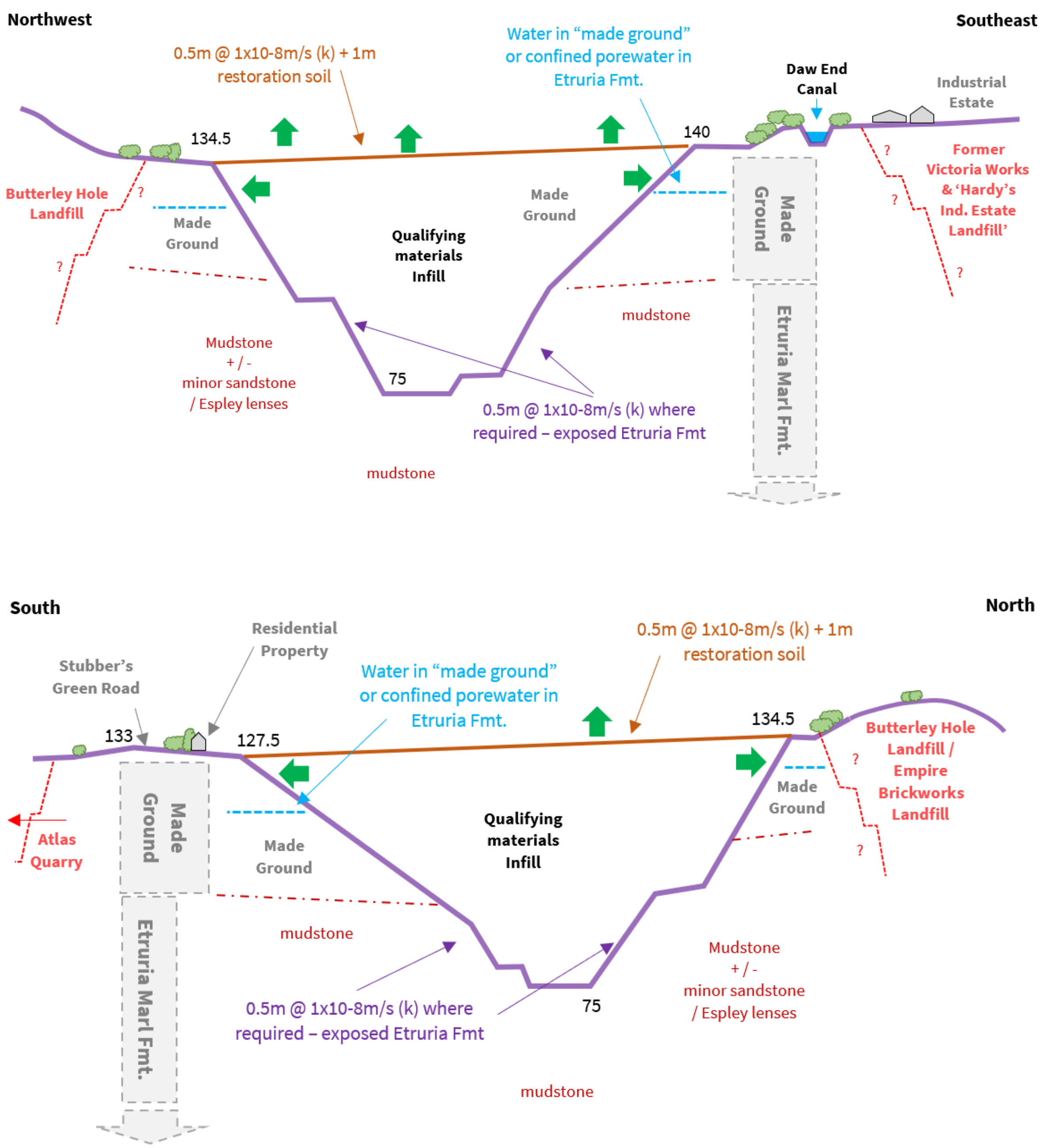


Brown infill denotes authorised landfill, pink denotes "historic landfill"

1.2 Conceptual Site Model

The Conceptual Site Model (CSM) used for this LFGRA is based on the site design, waste types and environmental setting data provided in the Environmental Setting and Installation Design Report for the Site (ESID, reference 5430-BLP-R-003-02) and on the principles of the conceptual model provided in GasSim 2.5 and the schematic site model in Figure 2 below.

Figure 2 Schematic Conceptual Site Model



Location of Section Lines are proved in the ESID, Figure 11.

Source

The void has been designed as per the detail specified in the supporting ESID (reference 5430-BLP-R-003-02) and will be constructed with a geological barrier (only against exposed in-situ strata) comprising re-engineered and compacted Etruria Formation bedrock across the sidewalls at a depth of 500 mm to a maximum permeability of $1x10^{-8}$ m/s.

The infill volume is calculated at 3.1Mm^3 (equivalent to 6.2M tonnes). The infilling is anticipated to have a duration of 20 years although material availability may alter the initial assumptions. Input rates are expected to be 310,000t/y, to account for any surplus or additional infill availability, a permitted maximum limit of 700,000t/y is proposed within the application. Installation phasing will progress in accordance with drawings ESID 5A, 5B and 5C.

Restoration will meet the objectives of the current planning application; selected materials will be utilised to assist in surface water control (ESID 6). A typical thickness of 1m of restoration soils is proposed over the cap for achieving the desired restoration profile, ~153,000m^3 is required for a final 1m surface layer over the site (area of 15.3ha), which equates to ~306,000t. The site will accept waste consisting primarily of excavation, construction/demolition wastes and similar materials that are inert or have a low level of contamination.

This will be enforced by rigorous waste pre-acceptance procedures, ensuring a low-risk source term, resulting in negligible volumes of gas and leachate generation within the waste mass. This is in comparison to the waste types deposited at consented nearby site (currently operational and closed) which have a higher gas producing potential, controlled by the gas extraction and management system on those sites.

Pathways

The pathways are defined as the environmental transport processes by which the pollutants move from the source to the receptors (as outlined in Figure 2). In the case of landfill gas there are two transport processes that should be considered: atmospheric dispersion and lateral migration.

Atmospheric dispersion of landfill gas emitted from the site is influenced by the prevailing wind direction and speed. Fugitive landfill gas emissions from uncapped wastes, exposed flanks or failures in an active landfill gas management system (pipework, gas wells, flare or gas engines) are most likely to be conveyed to receptors along this pathway.

Wind velocity and direction will affect the distance a fugitive gas emission travels and where it travels to. The presence of undulating topography, large structures, bunds and woodland in the vicinity of a site will increase the effective surface roughness i.e. turbulence. Higher wind speeds will also aid beneficial dispersion of emissions. Surface emissions are considered highly unlikely due to the negligible volume of gas predicted to be produced as a result of the low gas generation potential of the wastes to be accepted.

The deposited low permeability wastes will have a low/negligible biodegradable content and as such will not generate landfill gas. Lateral migration describes the transverse migration of landfill gas through an unsaturated subsurface by advection and diffusion.

On account of the low gas generation potential, it is considered that lateral migration is unlikely to occur. The lateral transport pathway (through the engineered basal and sidewall liner) and then in-situ Etruria Formation (at depth) or low-permeability back cast material (at surface) is extensive.

Where engineered, the Etruria Formation will be reworked to achieve a 500mm minimum thickness AGB, at a permeability no greater than $1x10^{-8}$m/s. In practice, the associated material can achieve a permeability range between $9.9x10^{-10}$ to $1.4x10^{-11}$m/s (Section 2.6, report reference 5430-BLP-R-003-02).

The ESID (Section 3.5) has outlined the extensive nature / cover of cast back materials that are present at the site's periphery, in places this is extensive in depth which is ~ 25.5m in thickness in close proximity to the residential property on Stubbers Green Road. The lateral distances between the infilled qualifying material to the borehole adjacent to the residential property on Stubbers Green Road (BH4S/BH4D) has been calculated at 28m (at surface) and 60m at the interface with the underlying bedrock (ESID Section 4.1).

Receptor

The surrounding geological system (and any contained groundwater beneath, or laterally) are not considered receptors. Receptors are discussed in further detail in section 1.3 below.

As noted above, regarding pathway lengths, the only nearby residential property is a considerable distance from the infill scheme (gas monitoring in recently installed monitoring installations will be undertaken for completeness (report reference 5430-BLP-R-009-02).

Additional information on surface receptors is provided below.

1.3 Site Location and Surrounding Land Use

A number of potential receptors need to be considered with respect to landfill gas. The generic categories are listed below:

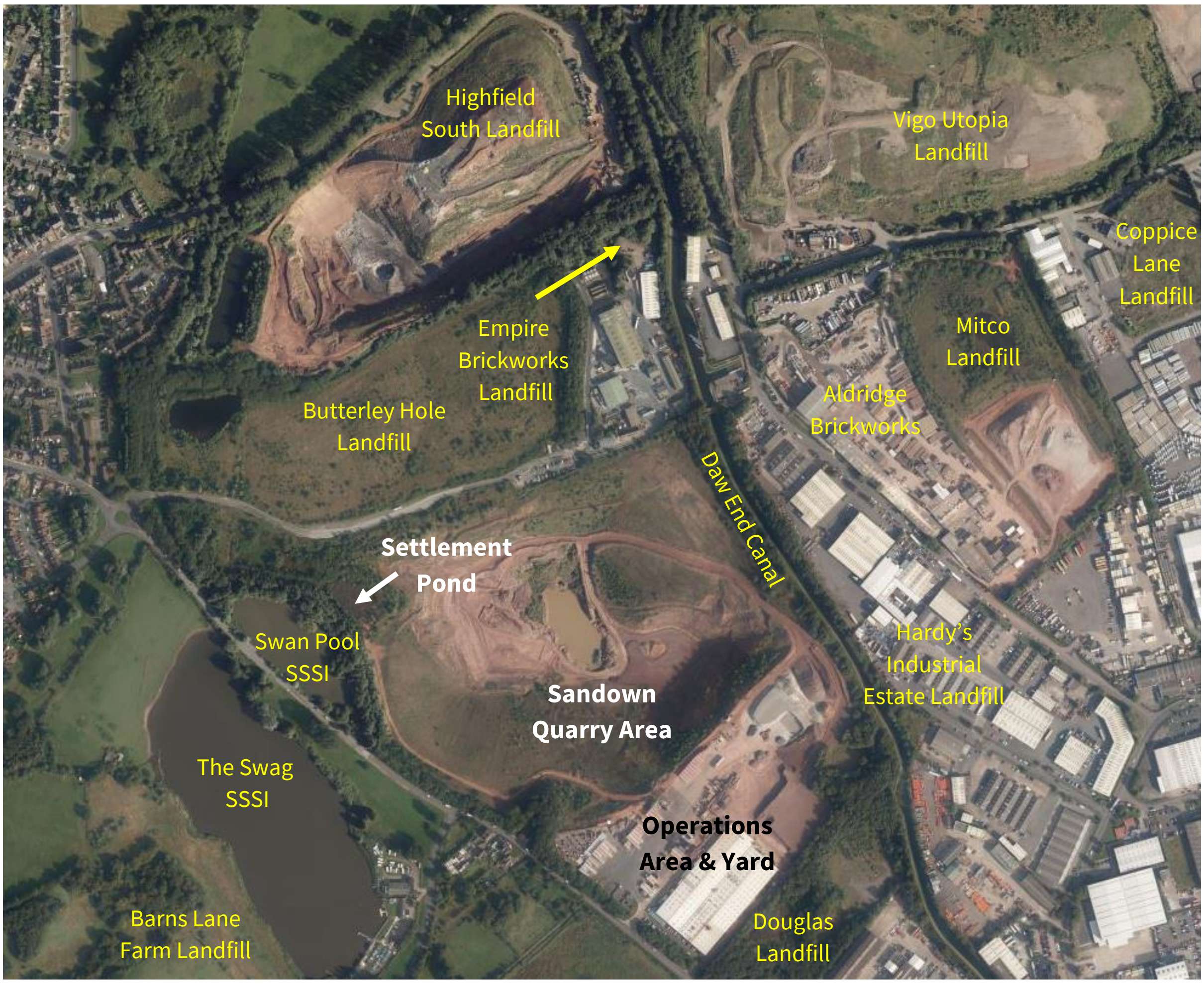
- Domestic dwellings;
- Other occupied buildings (offices, public buildings, schools etc);
- Sensitive habitats and environmental areas e.g. SSSIs;
- Public footpaths or bridleways;
- Major highways and minor roads;
- Open spaces, parks and farmland (crop damage);
- Air quality management zones.

A review of the sensitive receptors has been completed in relation to the site, a list of receptors listed in Table 1. Sensitive receptors and designated sites within 2km have been considered. A Sensitive Receptor Location Plan (reference ESID 2 and ESID 3) accompanies this application and should be referenced in conjunction with this risk assessment report.

Adjacent sensitive receptors to the site are limited (context and visual overview provided in Figure 3, there are SSSI's located adjacent to the boundary however as stated in the ESID report, "The

Natural England Website details" - "*Much of the reed swamp at Swan Pool has been lost to scrub encroachment and reedswamp at the Swag to horse grazing over last few decades. More recent ornithological advice is to work with landowners to restore the reedswamps and see what happens. Scrub control at Swan Pool will require a long-term programme taking into account existing wildlife interest such as other bird species and invertebrates, whereas a fence is required at the Swag to prevent grazing animals from eating off any emerging reedswamp growth. A stable water level is also required*". It is also noted that swallows on autumn passage no longer use the site.

Figure 3 Aerial Overview of Sandown Quarry



Only one residential property is located at the site boundary (receptor number 1) and most of the nearby land use is classed as industrial (Table 1, Figure 3).

The sites' location (within an extensive thickness of in-situ geological barrier) is considered to be a "low sensitivity setting". The potential for impact on nearby receptors is considered insignificant compared to the industrial land use nearby (Figure 3) and risk to human health is low when judged against the locations of historic landfill (Figure 1) many of which are not monitored and hence do not control potential gas emissions (e.g. Douglas Landfill to the south). Further information regarding amenity risk is provided in report 5430-BLP-R-004-02.

Table 1 Sensitive Receptor Review

Receptor No.	Receptor	Receptor Type	Approx. Distance from Site Boundary (m)	Direction from Site	Freq (%) Prevailing Wind Direction
1	Residential properties on Stubbers Green Road	Residential	20	SW	7
2	Residential properties on New Street	Residential	125	NW	4
3	Residential properties on Swan Pool Grove	Residential	130	W	5
4	Residential properties on Brook Meadow Road	Residential	150	W	5
5	Residential properties on Woodhaven	Residential	180	W	5
6	Residential properties on Broadheath Drive	Residential	240	W	5
7	Residential properties on Woodbridge Close	Residential	210	NNW	0
8	Ormiston Shelfield Community Academy	School	850	SE	9
9	St John's CE Primary School	School	1230	NNE	4
10	Leighswood Primary School	School	960	ESE	5
11	St Francis Catholic Primary School	School	520	WNW	8
12	Greenfield Primary School	School	870	W	5
13	Radleys Primary School	School	900	SW	7
14	Greenfields Allotments	Recreation	670	N	2
15	Aldridge Sailing Club	Recreation	200	SW	7
16	Open parkland around The Swag	Recreation	40	W	5
17	Recreation Ground	Recreation	450	W	5
18	Sandown Brickworks	Industrial/Commercial	40	S	14
19	Empire Industrial Estate	Industrial/Commercial	80	E	1
20	Veolia Empire Work (waste treatment)	Industrial/Commercial	15	N	2
21	Highfields South Landfill Site	Industrial/Commercial	250	N	2
22	Vigo Utopia Landfill Site	Industrial/Commercial	210	NNE	4
23	Linley Lodge Industrial Estate	Industrial/Commercial	590	SSW	10
24	Mercian Weldcraft Factory	Industrial/Commercial	280	SSE	22
25	Ibstock Brick Atlas brickworks	Industrial/Commercial	430	SSE	22
26	Ibstock Brick Atlas open quarry	Industrial/Commercial	410	S	14
27	Daw End Branch	Canal	15	E	1
28	Swan Pool	Pond	10	W	5
29	The Swag	Lake	75	W	5
30	Unnamed pond	Pond	90	NNW	0
31	Brick Kiln Pool	Pond	200	N	2
32	Unnamed pond	Pond	220	S	14
33	Unnamed pond	Pond	500	WSW	8
34	Unnamed pond	Pond	210	SSE	22
35	Unnamed pond	Pond	330	NE	4
36	On-site Drain – Highfield South	Site Drainage	320	N	2
37	Unnamed drain	watercourse	5	W	5
38	Unnamed drain	watercourse	20	NW	4
39	Unnamed drain	watercourse	300	W	5
40	Unnamed drain	watercourse	200	NNW	0

Receptor No.	Receptor	Receptor Type	Approx. Distance from Site Boundary (m)	Direction from Site	Freq (%) Prevailing Wind Direction
41	Unnamed drain	watercourse	50	S	14
42	Swan Pool and The Swag SSSI	SSSI	0		
43	Stubbers Green Bog SSSI	SSSI	50	S	14
44	Jockey Fields SSSI	SSSI	340	N	2
45	Daw End Railway Cutting SSSI	SSSI	1250	SSW	10
46	Dumblederry Lane LWS	LWS	220	SW	7
47	Anchor Brook Valley LWS	LWS	70	S	14
48	Daw End Branch Canal LWS	LWS	15	E	1
49	Stubbers Green LWS	LWS	15	W	5
50	Stubbers Green Road	Road	20	W	5
51	Barns Lane	Road	50	SW	7
52	Unnamed access road to Veolia Site	Road	20	ENE	2
53	Empire Close	Road	140	E	1

Distances in accordance with the proposed Sandown Quarry boundary

2 Landfill Gas Risk Assessment

2.1 The Nature of the Landfill Gas Risk Assessment

This risk assessment takes a qualitative approach to assess the impact of the site on sensitive receptors. Butterley Hole and the Empire Brickworks sites will not be considered further as part of this assessment, it is assumed that landfill gases are actively controlled and managed by the site operators. A qualitative risk screening exercise is proposed for Sandown Quarry.

2.2 Proposed Assessment Scenarios

Due to the low biodegradable content of the waste a qualitative screening exercise has been developed to assess the risk from landfill gas utilising a source-pathway-receptor approach. The permitted wastes proposed to be accepted comprise non-hazardous wastes with low organic content and negligible biodegradability consisting primarily of excavation, construction/demolition wastes and similar materials that are inert or have a low level of contamination.

This will be enforced by rigorous waste pre-acceptance procedures, ensuring a low-risk source term, resulting in negligible volumes of gas and leachate generation within the waste mass.

2.2.1 Lifecycle Phases / Scenarios

This assessment considers the landfill over all stages of its life, from first emplacement of waste at the site to the cessation of gas production at the site. It is considered that this assessment is representative of the predicted performance of the landfill over this time period.

The infilling volume is circa 3.1Mm^3. The commencement of infilling is dependent on issue of planning and permit approval however it is envisaged that void preparation (base final grading) that no engineered liner is required, see report 5430-BLP-R-003-02 and containment details provided therein. This infill is expected to take 20 years however based on actual waste inputs these timescales are subject to change.

2.2.2 Accidents and their Consequences

As required by LFTGN03 the Landfill Gas Risk Assessment should consider accident and failure scenarios. However due to the nature of the waste types to be accepted it is considered that none of the general categories of accident for landfill are applicable.

2.3 Landfill Gas Source Term

Environment Agency (Agency) guidance[1] states that biodegradable fraction (mainly cellulose and hemicellulose) is the portion of the waste which will undergo microbiological degradation to produce gas and liquids, although not all of this will be available for degradation. Inert landfills in contrast by their nature will have a minimal organic (biodegradable) content to the waste.

Section 4.4.1 of the above guidance references the degree to which waste composition can influence the generation of significant volumes of landfill gas. It states that a site that contains 75% or more inorganic wastes will produce minimal volumes of landfill gas (although this may still represent an environmental impact).

Consequently, risk assessment of sites which have accepted or will accept a low proportion of organic wastes is not expected to extend beyond the risk screening stage. The guidance recommends that the emphasis of a risk assessment be placed on rigorous waste acceptance procedures to control the nature of the wastes accepted to the site.

The types of waste to be deposited at Sandown Quarry will comprise non-hazardous soils and construction/demolition wastes with a low biodegradable content. Some residual Total Organic Carbon (TOC) is expected but this will tend to comprise of “hard” organic compounds such as resins and lignins which do not give rise to significant landfill gas production.

As such, a risk screening and hazard identification approach has been adopted to provide an assessment of potential impacts on local environment, health and amenity by:

- developing an understanding of Sandown Quarry in its environmental setting (the conceptual model), including the identification of the possible sources of a risk, the pathways and the potential receptors; and,
- consideration of the sensitivity of receptors in the vicinity of the site as identified in Section 1.3.

2.3.1 Adjacent Sites

There is no requirement to consider this source term further.

[1] Environment Agency (2004). LFTGN03: Guidance on the Management of Landfill Gas.

2.3.2 Sandown Quarry Landfill

The site will predominantly receive non-hazardous soils and construction/demolition wastes with a low biodegradable content and similar in physical characteristics to inert wastes. This will be very similar in nature to the material deposited at waste recovery sites and comprise mainly a mixture of excavated natural soils and made ground. The main components in these wastes will be clay, soil, silt, rock, brick, concrete, glass, sand, ash, clinker and slag.

Gas generation from any waste is associated with the proportion of organic matter which can be broken down by microorganisms. The organic content of natural soils varies greatly as described in the British Standard for Soil Descriptions BS5930:1999+A2:2010 and paragraph 41.4.6 of the standard provides details of the typical organic content of soils. An organic clay or silt can contain between 5 and 10% organic material. Table 2 below describes the range between slightly organic and very organic soils.

Table 2 Organic Content of Soils (BS5930:1999 Para 41.4.6)

Term	Organic Weight % of dry mass
Slightly Organic	2-6
Organic	6-20
Very Organic	>20

One method of measuring the organic content of soils is the assessment of the Total Organic Content (TOC) as determined by laboratory testing. TOC analytical technique however does not accurately reflect the organic component of a soil that is readily biodegradable.

The method first involves quantification of the proportion of inorganic carbon in the material by acidification. A separate sample of the same material is then subject to high temperature combustion and catalytic oxidation with quantification of the organic carbon by measurement of the liberated carbon dioxide. The inorganic proportion is accounted for in subsequent calculations prior to the TOC value being reported.

The TOC testing will not give an indication of the readily biodegradable potential of the material nor can it be used to determine how much gas will be produced. The TOC test is therefore likely to be an over-estimate of the gassing potential of the waste and should not be considered in isolation.

A CL:AIRE research bulletin[2] also discussed TOC in natural soils.

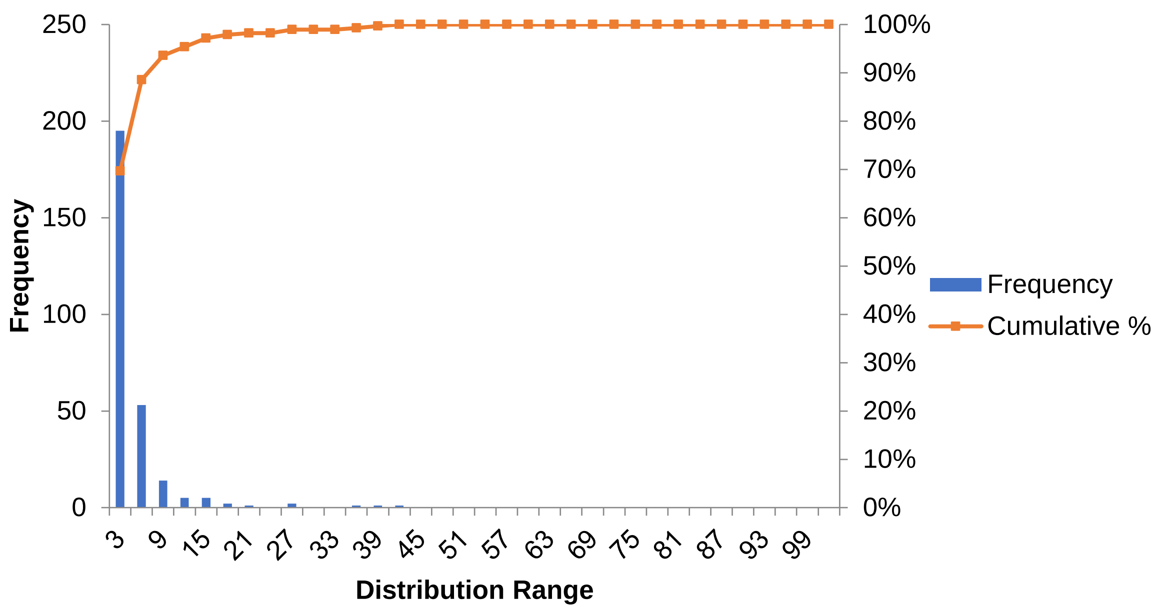
It describes the prevalence of large complex organic compounds (stabilised organic matter) such as resins, lignins, waxes or heavy molecular weight hydrocarbons which few microbes can degrade. Other more degradable compounds are bound up in the soil structure and cannot be reached by microbes. These compounds can be exposed during ground disturbance and could explain initial high concentrations of methane recorded from boreholes after they have been recently drilled. These concentrations subsequently reduce to negligible values which are more reflective of the low gas generation potential ground they were installed into.

[2] CL:AIRE (2012). A Pragmatic Approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17. November 2012.

ByrneLooby (formerly TerraConsult Ltd) carried out a review of waste testing data from site investigations undertaken across the northwest of England from 2002 to 2014. This data is considered to be representative of the demolition and excavation waste typically available to a landfill activity of this type.

280 TOC values had associated Dissolved Organic Carbon (DOC) values (from 2:1, 8:1 and 10:1 leachability tests expressed as mg/l). Figure 4 shows the frequency distribution of TOC values recorded.

Figure 4 TOC frequency



The significant majority of TOC values are less than 3 % (WAC for inert landfill sites) at 70 % of the sample group and 93 % were less than 10 %. The most likely value to be recorded was 2 % or less (53 % of the sample group). The highest TOC recorded was 41.2 %. The majority of TOC values recorded are comparable with the figures for naturally occurring slightly organic material given in Table 2. A much smaller proportion compare well with organic material.

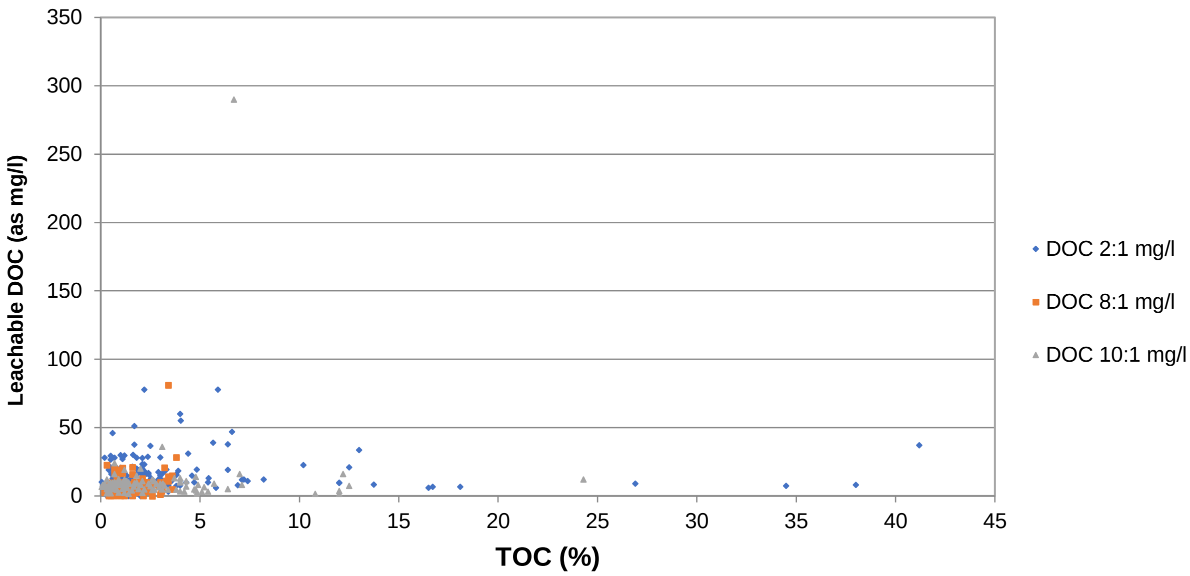
Based on the data from the review, it is likely that the type of material to be brought to site will have a TOC of less than 10 %. This material is likely to have a low DOC potential and would meet the WAC for inert landfill sites (even where the TOC would not).

2.3.3 DOC and TOC

Figure 5 shows the relationship between TOC and DOC where appropriate data was available. Leachable DOC concentrations are largely comparable with up to 10 % TOC within each liquid to solid ratio (L/S) data set. DOC (mg/l) was lower at the higher TOC values. The highest total leachable DOC (10:1 L/S mg/kg) was half the WAC limit for inert landfill sites and appeared to reduce at concentrations higher than 10 % TOC, although this may reflect the size of the data set.

It is likely that if the TOC content of the soils accepted at site was limited to 10 %, the DOC value will meet the WAC limit for inert landfill sites.

Figure 5 Leachability of DOC in relation to TOC



A recent study[3] reviewed the gas generation potential of Mechanical Biological Treatment (MBT) wastes. This material had previously been subject to biological treatment (e.g. composting or anaerobic digestion) resulting in a stabilised material with a lower biodegradable potential. This material was then placed in Lysimeters under a variety of conditions to establish how much methane may be produced when landfilled.

Although the age and type of waste will be different, the stabilised MBT residue is considered to be a very conservative representation of gas generation from excavated soils.

The study found that waste with a TOC of ≤ 18 % and DOC of ≤ 300 mg/l were inhibited from producing significant volumes of gas. Water content was the primary limiting factor, followed by TOC / DOC and other factors such as temperature.

The calorific value of the gas produced from MBT residue was found to be negligible and it was suggested conventional techniques for gas treatment may not be economical. Simple oxidation of the gas through the cap or soil layers was proposed as a sustainable solution for oxidation of gas produced from landfills containing MBT or old landfills.

DOC represents the readily soluble proportion of the tested material released under quite aggressive laboratory conditions i.e. mechanical size reduction and subsequent continual agitation. Its solubility means it may be more susceptible to microbiological assimilation and biodegradation, which under anaerobic conditions may result in methane generation. The absence of a strong

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[3] S. Bohn And J. Jager (2011). Low Gas Emissions of Mechanically and Biologically Treated Waste and Microbial Methane Oxidation as an Adapted Method for Mitigation of Emissions. Proceedings Sardinia 2011, Thirteenth International Waste Management and Landfill Symposium S. Margherita di Pula, Cagliari, Italy; 3 - 7 October 2011

relationship between increasing TOC and DOC from excavated soils suggests gas generation from these types of waste may be low due to the low leachability and otherwise biodegradable DOC.

The evidence from landfill sites taking mainly excavated soils with comparable TOCs to the above data is that they do not give rise to significant gas production. Average bulk gas flows recorded from boreholes installed in a hazardous landfill site (Eardswick Hall) and a soils site (Sea View Farm 2) were 0.5 to 0.6 l/hr.

The hazardous landfill WAC limits TOC in waste inputs to Eardswick were 5%. Sea View Farm 2 was permitted to accept inert waste with no more than 5% in any one load of materials with a biodegradable potential such as wood or wood products.

2.4 Landfill Gas Generation

ByrneLooby has direct knowledge of similar sites / permitted schemes, the gas data collected by the associated operators (which accept waste types directly comparable to those proposed to be accepted at Sandown Quarry), consistently records methane at less than the limit of detection with no recordable gas flow.

This is considered to be representative of the negligible gas production expected as a result of the low biodegradable content of the wastes to be accepted. However, to allow the estimation of potential landfill gas generation in the site the flow rate from Eardswick and Seaview Farm has been extrapolated up to the proposed surface area of the Site (15.3ha).

Assuming a uniform depth, a gas well zone of influence of 5 m radius (area 78m^2) and a flow rate of 0.0006 m^{3}hr^{-1}, it can be estimated that Sandown Quarry Landfill will produce 1.2 m^{3}hr^{-1} of bulk landfill gas. If the maximum flow rate recorded at Eardswick was used (0.028 m^{3}hr^{-1}) this would give a total of 53m^{3}hr^{-1}.

In the light of the above, the waste acceptance criteria for the installation will include for a number of restrictions to exclude readily biodegradable wastes at the site. The full criteria are set out in the operators Waste Acceptance Procedures but with respect to the Landfill Gas Risk Assessment the relevant restrictions are as follows:

- Exclusion of readily biodegradable wastes using EWC codes;
- On-site rejection procedures to visually identify and exclude waste loads that appear to contain cellulose based materials (paper, wood, vegetation, topsoil, cardboard); and,
- Imposition of a conservative 10% TOC maximum limit on waste soils accepted at the site.

It is also intended to adopt the additional restrictions on "active" waste types as relevant to the Landfill Tax (Qualifying Materials) Order 2011 (as amended) which will further control the biodegradable content of wastes deposited at the site.

The estimated maximum production of 53m^{3}hr^{-1} is comparable to the threshold level of 50m^{3}hr^{-1} suggested in Agency document LFTGN03 'Guidance on the Management *of Landfill Gas*' (September 2004) below which active gas control and treatment is not required. Based on data from similar sites it is likely that volume of gas produced will be significantly lower than this.

However the conservative scenario above assumes 128 boreholes per hectare were installed, significantly more than the guideline value of 2 per hectare to support a permit surrender application.

2.5 Risk to the Environment and Human Health

2.5.1 Landfill Gas Emissions

The screening exercise of the potential landfill gas production based on the source term of similar sites suggest that landfill gas production will be negligible and peak directly after the end of landfilling. Based on the waste inputs commencing in 2024 and ceasing in 2044 (based on the anticipated waste input) the peak production of landfill gas and peak methane production are estimated to occur in 2044.

The overall volumes of landfill gas to be produced are considered negligible yet representative of the potential landfill gas generation from the waste types to be accepted. In risk assessment terms therefore the potential for environmental harm from Sandown Quarry is negligible and in this respect the conditions are such that the surrender criteria would be met.

The data recorded from the Eardswick, Sea View Farm and Escrick sites (not operated by the applicant) indicates that the gas volumes are a very conservative estimate of landfill gas production. It is therefore not only likely that gas production will rapidly decline, it will also be to a level where the site will fulfil the criteria for permit surrender (as set out in Agency online guidance[4]). The site is surrounded by geology of Etruria Formation (primarily marl / mudstone) which will act to mitigate against lateral migration from the site. As Sandown Quarry Landfill is considered to produce negligible amounts of landfill gas the potential for lateral migration is considered negligible.

The closest domestic dwellings are the residence approximately 20m to the southwest of monitoring points BH22-04S and BH22-04D on Stubbers Green Road which are an additional 20 m from the site / infill (distance measured "at surface"). Based on the negligible amount of gas production and supported by experience of similar soil sites it is considered the predicted likely concentrations of surface emissions at the site boundary to be negligible. It is concluded that landfill gas does not pose a significant risk to the surrounding environment specifically the receptors identified in Section 1.3.

2.5.2 Atmospheric Dispersion and Odour

The negligible volumes of landfill gas produced are not considered to give rise to any significant contribution to the effects of global warming or ozone depletion. Assessment of the potential for an odour nuisance is more subjective. Due to the nature of the waste types to be deposited comprising non-hazardous soils and construction and demolition wastes with low biodegradable content odour generation will be negligible as they will not contain materials or compounds that are likely to give risk to odour.

[4] https://www.gov.uk/government/collections/environmental-permit-application-forms-to-surrender-a-permit

2.5.3 Sub-Surface Lateral Migration and Vegetation Stress

Sub-surface landfill gas migration beyond the boundary of the site can give rise to a number of potential risks, including explosion, asphyxiation, toxicity, and vegetation damage. Should the fugitive gas then be liberated to atmosphere, there are the additional risks of odour nuisance and contributions to global warming.

Lateral migration has not been considered due to the negligible gas production estimated for the site. In addition, the site will have an *in-situ* basal geological barrier (>5m of mudstone / marl) and engineered sidewall liner of low permeability site-won materials (to mitigate against any "permeable layers" exposed on final void preparation). This will prevent any potential lateral gas migration however it is not considered likely due to low gas generation potential of the wastes to be accepted.

2.5.4 Landfill Gas Completion Criteria

Gas production rates will be insufficient to support any active extraction or treatment.

2.5.5 Residual Gas Potential

A site's potential for future gas generation can be assessed via an analysis of the solid wastes remaining in the landform, with the results expressed as the biological methane potential (BMP). However due to the type of waste to be deposited the biological methane potential is negligible.

2.5.6 Gas Concentration and Flow Rates

Agency guidance document 'Landfill (EPR 5.02) and other permanent deposits of waste; How to surrender your environmental permit (version 2, 13th December 2012) provides criteria for assessing landfill completion based upon the results of monitoring of gas concentrations or flow rates. This gives three scenarios when the landfill gas surrender criteria for landfill can be met.

Scenario 1

in-waste gas methane concentration of ≤1.5 % v/v and carbon dioxide of ≤5 % v/v (minimum 12 data sets over 2 consecutive years)

Scenario 2

in-waste gas methane concentration of ≤5 % v/v and carbon dioxide of ≤10 % v/v (minimum 12 data sets over 2 consecutive years) and Qhgs* is <0.7 l/hr and the flow in any borehole is ≤ 70 l/hr

Scenario 3

in-waste gas methane concentration of ≥5 % v/v and carbon dioxide of ≥10 % v/v (minimum 24 data sets over 2 consecutive years) and Qhgs* is <0.7 l/hr and the flow in any borehole is ≤ 70 l/hr

*Qhgs: Site Characteristic hazardous gas flow rates as defined by BS 8485:2015.

It is proposed that such assessment criteria are considered in a site-specific context within a Completion Risk Assessment for the site which will be submitted to the Agency at an appropriate point in the site's lifecycle. It is likely that the site will be surrendered prior to the adjacent sites to the north.

3 Landfill Gas Management Plan

3.1 Control Measures

Based on a review of GasSim modelling exercises undertaken for sites with similar waste composition inputs, the predicted volume of landfill gas produced by the site is considered highly likely to be significantly lower than the indicative threshold level of 50 m^3hr^{-1} suggested by Agency guidance where active gas control and treatment (flaring and utilisation) would be required. The nature of the waste deposits (low permeability soils and construction and demolition wastes) to be deposited will also make it very difficult to extract gas from the site.

The main control on the production on gas is by ensuring that the waste received at the site contains low proportions of biodegradable materials. Additional controls on the deposit of wastes that contain odorous substances will prevent any potential odour nuisance. These would include exclusion of such wastes or rapid covering during placement.

Notwithstanding this, measures will be implemented to ensure that the landfill gas production is monitored to confirm the basis of the qualitative risk model. As a precautionary measure, the site design provides for the installation of retro-drilled in-waste gas monitoring points and additional gas monitoring boreholes around the perimeter of the site.

3.2 Monitoring and Sampling

In-Waste Boreholes

It is intended to provide the site with in-waste monitoring installations. As the waste is expected to be inactive, the in-waste gas monitoring regime will meet the current landfill gas surrender criteria monitoring requirements. Following completion of capping in-waste gas monitoring boreholes / probes will be retro-installed (2 per hectare) with a 3 m stand-off from the top of the Artificial Geological Barrier (0.5m @ $1x10^{-8}$m/s) where present or interface with the underlying cast back / interbreed and overburden. The specifications of the borehole installations will be agreed with the Agency as part of the CQA process. Following installation of gas wells / probes, gas will be monitored in accordance with Table 3.

Table 3 In-waste Gas Monitoring Schedule

Monitoring Point	Monitoring Frequency		
	Operational	Post-Operational	Parameter
In-waste gas monitoring boreholes / probes ELS-GP01 to ELS-GP30	Quarterly	Quarterly	Methane, Carbon Dioxide, Oxygen and Gas Balance (% v/v), Gas Flow (l/hr), Relative pressure (mBar), Atmospheric Pressure (mBar) Water level and base level

The surface area for the site is ~15 Ha, hence 30 probes are proposed (to be installed post capping / restoration).

Perimeter Boreholes

3 perimeter gas / groundwater monitoring boreholes have been installed around the site (BH22-01, BH2-02S and BH22-04S), placed adjacent to the primary receptors to sample current and future ground gas conditions. Further details are provided in ESID 5430-BLP-R-003-02 and the monitoring plan that supports this application, report 5430-BLP-R-009-02. The primary receptor is the residential property on Stubbers Green Road, monitoring borehole BH22-04S is located in-between the site and the property.

Through baseline data collection however it has been established that it is not possible to collect gas samples from BHP-05, BHP-06 and BHP-07 (flush borehole covers with ground level (those pre-existing site boreholes identified at the onset of the permit application process). If possible, a gas bung will be added to BHP-07 (the deepest installation of ~51m) and utilised / included for future monitoring. Gas monitoring is not proposed for the shallow (<4m deep boreholes BHP-06 and <1m deep BHP-05).

The proposed gas monitoring schedule is detailed in Table 4 below.

Table 4 Perimeter Gas Monitoring Schedule

Monitoring Point	Monitoring Frequency		Parameter
	Operational	Post-Operational	
At landfill gas monitoring boreholes shown on drawing number ESID 12 BH22-01, BH22-02S, BH22-04S, BH22-04D, BHP-03S, BHP-07	Monthly	Quarterly	Methane, Carbon Dioxide, Oxygen and Gas Balance (% v/v), Gas Flow (l/hr), Relative pressure (mBar), Atmospheric Pressure (mBar)
	Quarterly	Quarterly	Water level and base level

3.3 Landfill Gas Data Review

A review of in-waste gas monitoring data from sites accepting wastes that are proposed for Sandown between 2018 to 2023 has been undertaken due to the directly comparable waste types accepted. Methane was recorded consistently at 0% v/v and carbon dioxide was recorded at 0 % v/v excluding two readings of 0.1% v/v. No flow has been recorded in any of the in-waste gas wells. This is considered to be representative of the low gas generation due to the low biodegradable content of the wastes accepted.

Environmental baseline monitoring post May 2022 from the monitoring locations depicted on Figure 11 within the ESID (drawing ESID 12) has not reported the presence of methane at any location, all concentrations are reported at <0.1%. Monitoring schedules and frequencies proposed for future monitoring are detailed in report 5430-BLP-R-009-02.

Table 5 Perimeter Gas Monitoring (May 2022 – May 2023)

Sample location	Date	Atmospheric pressure	Flow	Methane %	Carbon Dioxide %	Oxygen %	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	GSV CH_4 (% v/v)
BH22-01	12/05/2022	1002	<0.1	<0.1	<0.1	20.6	<1	<1	-
BH22-04S	12/05/2022	1003	<0.1	<0.1	<0.1	20.6	<1	<1	-
BH22-04D	12/05/2022	1003	<0.1	<0.1	<0.1	20.4	<1	<1	-
BH22-01	30/06/2022	994	<0.1	<0.1	4.7	11.6	<1	<1	0.0001
BH22-04S	30/06/2022	994	<0.1	<0.1	6.9	5.6	<1	<1	0.0001
BH22-04D	30/06/2022	994	<0.1	<0.1	0.8	19.5	<1	<1	0.0001
BH22-02S	30/06/2022	994	<0.1	<0.1	3.2	17.1	<1	<1	0.0001
BH22-02D	30/06/2022	995	<0.1	<0.1	0.7	19.4	<1	<1	0.0001
BH22-01	29/07/2022	1002	<0.1	<0.1	-	-	<1	<1	0.0001
BH22-04S	29/07/2022	1001	<0.1	<0.1	6.9	6.8	<1	<1	0.0001
BH22-04D	29/07/2022	1001	<0.1	<0.1	1.2	19.9	<1	<1	0.0001
BH22-03S	29/07/2022	1002	<0.1	<0.1	0.1	20.9	<1	<1	0.0001
BH22-03D	29/07/2022	1002	<0.1	<0.1	0.1	20.9	<1	<1	0.0001
BH22-02S	29/07/2022	1001	<0.1	<0.1	1.8	18.1	<1	<1	0.0001
BH22-02D	29/07/2022	1001	<0.1	<0.1	0.3	20.1	<1	<1	0.0001
BH22-01	15/08/2022	985	<0.1	<0.1	13.3	0.1	<1	<1	0.0001
BH22-04S	15/08/2022	986	<0.1	<0.1	2.1	13.3	<1	<1	0.0001
BH22-04D	15/08/2022	986	<0.1	<0.1	1.3	9.9	<1	<1	0.0001
BH22-03S	15/08/2022	986	<0.1	<0.1	0.1	20.5	<1	<1	0.0001
BH22-03D	15/08/2022	986	<0.1	<0.1	0.1	20.5	<1	<1	0.0001
BH22-02S	15/08/2022	986	<0.1	<0.1	2.3	17.7	<1	<1	0.0001
BH22-02D	15/08/2022	986	<0.1	<0.1	0.4	20.1	<1	<1	0.0001
BH22-01	09/09/2022	989	<0.1	<0.1	12.7	0.1	<1	<1	0.0001
BH22-04S	09/09/2022	989	<0.1	<0.1	1.7	14.1	<1	<1	0.0001
BH22-04D	09/09/2022	989	<0.1	<0.1	1.8	8.3	<1	<1	0.0001
BH22-03S	09/09/2022	989	<0.1	<0.1	0.1	20.5	<1	<1	0.0001
BH22-03D	09/09/2022	989	<0.1	<0.1	0.1	20.5	<1	<1	0.0001
BH22-02S	09/09/2022	989	<0.1	<0.1	2.6	15.9	<1	<1	0.0001
BH22-02D	09/09/2022	989	<0.1	<0.1	0.7	18.7	<1	<1	0.0001
BH22-01	18/11/2022	971	<0.1	<0.1	0.9	20.3	<1	<1	0.0001
BH22-04S	18/11/2022	972	<0.1	<0.1	<0.1	20.3	<1	<1	0.0001
BH22-04D	18/11/2022	972	<0.1	<0.1	0.2	20.2	<1	<1	0.0001
BHP-03S	18/11/2022	972	<0.1	<0.1	0.2	20.3	<1	<1	0.0001
BHP-03D	18/11/2022	972	<0.1	<0.1	0.3	20.3	<1	<1	0.0001
BH22-02S	18/11/2022	972	<0.1	<0.1	0.2	20.3	<1	<1	0.0001
BH22-02D	18/11/2022	972	<0.1	<0.1	0.5	20.3	<1	<1	0.0001
BH22-01	06/02/2023	1022	<0.1	<0.1	10.1	2.4	<1	<1	0.0001
BH22-04S	06/02/2023	1022	<0.1	<0.1	0.8	17.8	<1	<1	0.0001
BH22-04D	06/02/2023	1022	<0.1	<0.1	3.5	2.6	<1	<1	0.0001
BHP-03S	06/02/2023	1022	<0.1	<0.1	0.7	20	<1	<1	0.0001
BHP-03D	06/02/2023	1022	<0.1	<0.1	0.2	20.1	<1	<1	0.0001
BH22-02S	06/02/2023	1022	<0.1	<0.1	<0.1	20.2	<1	<1	0.0001
BH22-02D	06/02/2023	1022	<0.1	<0.1	0.3	20.2	<1	<1	0.0001
BH22-01	15/05/2023	1003	<0.1	<0.1	10.9	0.2	<1	<1	0.0001

BH22-04S	15/05/2023	1003	<0.1	<0.1	0.6	19.1	<1	<1	0.0001
BH22-04D	15/05/2023	1003	<0.1	<0.1	1.8	17.4	<1	<1	0.0001
BHP-03S	15/05/2023	1003	<0.1	<0.1	0.4	19.8	<1	<1	0.0001
BHP-03D	15/05/2023	1003	<0.1	<0.1	0.1	20.1	<1	<1	0.0001
BH22-02S	15/05/2023	1003	<0.1	<0.1	0.1	20.4	<1	<1	0.0001
BH22-02D	15/05/2023	1003	<0.1	<0.1	0.2	20.4	<1	<1	0.0001

* Unable to collect gas samples from BHP-05, BHP-06 and BHP-07 (flush cover with ground level, pre-existing boreholes)

3.4 Contingency Action Plan

The action plan is to be implemented by the site manager in the event of the following:

- concentrations in the perimeter boreholes breaching the permit compliance level;
- Abnormal, adverse trends in monitoring data;
- Operational problems;
- Reported events (e.g. odour complaints);
- Confirmed migration events or uncontrolled releases of landfill gas; and,
- Confirmed adverse impacts on local air quality.

The timescales for implementing remedial actions at the site, which is considered a low-risk site, are presented in Table 6.

Table 6 Site Monitoring Borehole Response Action Target Timescales (Recommended within ICoP Guidance)

		Site Risk		
		High	**Med**	**Low**
Outcome	**Action**	**Completion**		
Additional Monitoring - Exceedance of Action Level				
Conc above action level	Re-monitor	24hrs	48hrs	7days
Conc still above action level	Verify conceptual model and plan for extended pathway assessment if required	1wk	1wk	2wk
Extended Pathway Assessment				
Conc above action level	Investigate sources and pathways	1wk FW 3wks Rep	2wk FW 4wks Rep	3wk FW 5wks Rep
	In depth assessment of containment performance	2wk FW 3wks Rep	3wk FW 4wks Rep	3wk FW 4wks Rep
Conc still above action level	Verify conceptual model	4wks Rep	5wks Rep	6wks Rep

Outcome	Action	High	Med	Low
Additional Monitoring - Exceedance of Permit Limit				
Conc above compliance level	Re-monitor every day	6hrs	24hrs	48hrs
	Verify conceptual model and plan for extended pathway assessment if required	48hrs	1wk	2wk
Extended Pathway Assessment				
Conc above compliance level	Off-site receptor analysis and risk action plan	1wk Rep	2wk Rep	3wk Rep
	Investigate sources and pathways	1wk FW 3wks Rep	2wk FW 4wks Rep	3wk FW 5wks Rep
	In depth assessment of containment performance	2wks FW 3wks Rep	3wks FW 4wks Rep	3wks FW 4wks Rep
Conc still above compliance level	Verify conceptual model and review system performance	4wk Rep	5wk Rep	6wk Rep
	Additional contingency actions	4wk Rep	5wk Rep	6wk Rep

FW - Field Work, Rep - Report. hrs - Hours, wk - Week

Response

If any of the events identified above occur, the following course of action will be implemented iteratively until the cause of the issue has been identified and any adverse effects have ceased or been remediated.

- Report to the Agency in accordance with the permit if the compliance level is exceeded and on progress with any resulting actions detailed below.
- Review the monitoring data to identify any other associated rising trends in perimeter methane / carbon dioxide concentrations.
- Repeat the gas monitoring as soon as possible but no later than 7 days to confirm the reproducibility of data. If the repeat reading is below the compliance / action level then no further investigations are required. A watching brief will be maintained on all boreholes.
- Review the in-waste monitoring data to identify if gas production has increased. The historic data set will be reviewed for trends which may indicate an increase in gas production.
- If in-waste gas production is within its normal range, / or leachate quality is within its normal parameters, then a review of alternative sources / causes of ground gas production will be instigated. This will include changes to site engineering e.g. capping or lining, agricultural practices outside the site boundary such as manure spreading or drainage works.
- If migration is persistently observed in a specific borehole the monitoring data will be reviewed and changes implemented as required. If the borehole is in a sensitive area e.g.

close to housing then consideration will be given to increasing monitoring to a weekly frequency in that borehole or area.

- The surrounding area will be checked for signs of gas or leachate escaping or vegetation die back.
- If elevated levels continue, the area of the migration will be audited to establish potential remediation works to be carried out if required.

In the unlikely event that remedial action is required, a proposal will be provided to the Agency for approval. This may include one or more of the following:

- A gas pumping trial in accordance with Agency guidance to confirm the assumptions of the Landfill Gas Risk Assessment and establish whether the gas is being produced at a significant rate.
- An options appraisal to establish the most practical and cost effective gas control methodology for the management of negligible volumes of landfill gas (e.g. biofilters, or low-calorific flares).
- Additional extraction or monitoring points as necessary based on the revised risk assessment / pumping trial.
- A report on the effectiveness of the revised control system after an appropriate period of monitoring.

3.5 Maintenance of Perimeter Monitoring Infrastructure

The gas monitoring installations shall be inspected during each routine monitoring visit to ensure that they are fit for purpose. In the event that repairs are required these shall be undertaken within a period of one month. Examples of the kind of issues to be considered are:

- Wear and tear: damage by machines, plant or through vandalism. Functioning of seals and valves;
- Access: are the monitoring points accessible safely;
- Settlement: is the installation leaning over, has it dropped noticeably;
- Surface water ingress: is there water pooling around the base of the installation, is there signs of previous ponding / rivulets of running water in the vicinity of the installation.

If any of the above is apparent at any of the installation, then the site manager and relevant personnel should be informed immediately.

Should any of the monitoring points become damaged to such an extent that suitable data cannot be recorded; alternative monitoring locations will be proposed and agreed with the Agency. If no suitable alternatives are present, then the damaged wells will be either repaired or replaced if practicable. The nature and location of any replacement, as well as the methods to be used, would be approved by the Agency prior to any works being undertaken.

4 Conclusions

An assessment of potential impacts on local environment, health and amenity of landfill gas from the site has been carried out using a risk screening and hazard identification approach.

A qualitative assessment of the potential volumes of landfill gas that may be produced at the site and the potential risk to receptors has been undertaken. The wastes are non-hazardous soils and construction demolition wastes with a low biodegradable content, and as such the expected volumes of landfill gas are considered to be negligible. The estimated peak production for bulk landfill gas is significantly lower than the Agency threshold which indicates that active management of landfill gas is not required.

Reference has been made to post-closure gas monitoring data recorded from a completed site filled with wastes similar to that proposed for the site. Actual gas production was found to be negligible and therefore the estimated gas volume is likely to be very conservative. This qualitative risk assessment does not include an assessment of the landfill gas production for adjacent sites to the north.

A limited number of receptors have been identified, however due to the negligible volumes of gas being produced it is concluded that landfill gas from Sandown Quarry Landfill does not pose a significant risk to the surrounding environment. The potential for odours arising from the placement of wastes is negligible due to their low biodegradable content.

The gas management plan reflects the low risk that the site poses to the surrounding environment in that no gas flaring or utilisation will be required.

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