Gas Risk Assessment

Radlett SRFI Area 2

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Comments

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1. Introduction

1.1 The Brief

Waterman Infrastructure & Environment Limited ("Waterman") has been appointed to prepare an application for an Environmental Permit (EP). The EP application is to authorise the permanent deposit of waste on land as a recovery activity. The waste recovery activity is for site-derived waste to be used in the construction of landscape bunds associated with the construction of the Radlett Strategic Rail Freight Interchange (SFRI), located at North Orbital Road, Upper Colne Valley, Hertfordshire, AL2 2ET – specifically the two landscape bunds on Area 2.

SEGRO Radlett Ltd is the master developer – the party responsible for bringing the scheme to fruition. It has appointed VolkerFitzpatrick Limited (VFL) to undertake the earthworks including bund construction and other enabling activities. VFL is therefore the EP applicant and will be the EP operator.

A Gas Risk Assessment (GRA) is required to support the waste recovery EP application.

1.2 Context

Through the Radlett SRFI scheme SEGRO Radlett Ltd proposes to develop an intermodal terminal, with rail and road distribution units. The SRFI is located to the south of St. Albans, adjacent to the M25 and Midland Main line (MML) railway. The terminal will be serviced by a new dual track rail chord connected to the MML.

The SRFI comprises a 419-hectare (ha) development area that is sub-divided into eight plots referred to as Areas 1 to 8. The areas have the following proposed uses:

- Areas 1 (146 ha) and 2 (26 ha) – the SRFI Development Area. Area 1 will comprise an intermodal terminal and a rail and road served distribution facility consisting of several large warehouses. The rail chord connecting Area 1 to the MML will run through Area 2. Area 2 will also feature two landscape bunds (LS1 and LS2) that will help to screen the SRFI from public view and provide acoustic screening; and
- Area 3 to 8 (247 ha) – will be developed with additional works and landscaping to provide publicly accessible open land and a community forest.

The Areas are shown on plan "Different Development Phases (Areas 1 – 8) of the SRFI"" (D-ESSD1A - drawings are to be found in the separate "ESSD drawings and information bundle").

To enable construction of the SRFI, earthworks are required to prepare the SRFI Development Area as summarised below:

Area 1

Earthworks material will be excavated from the northern half of Area 1 where the levels need to be lowered to enable access from the public highway to the north, to install surface water flow attenuation features and to create suitable development platform levels. The cut will be used to raise levels across the southern half of Area 1, to construct landscape bunds around the perimeter of Area 1 and to construct the landscape bunds on Area 2.

Area 2

Excavation is required in Area 2 to construct the new rail chord linking the MML and the SRFI – the rail chord needs to pass under the MML. Some of the excavation will be into historic landfill, with the waste arising to be processed by mobile treatment EP to generate useable earthworks material (i.e. meeting the specification for the works) with the unusable waste despatched for recovery or disposal elsewhere. The

waste recovered from processing the historic landfilled waste as well as restoration soils and capping material from Area 2 and excavation arisings cut from Area 1 will be used to construct the landscape bunds on Area 2.

The cut and fill locations across Areas 1 and 2 are shown on plan "Earthworks Analysis Cut and Fill Volumes" (D-ESSD4A).

Regulatory Control of Earthworks

Pre-application liaison has been undertaken with both local (Hertfordshire and North London) and national (Permitting Support Centre) EA teams, seeking to establish the waste / non-waste status of various excavation arisings and the appropriate mechanisms to regulate the use of the arisings as earthworks materials. Aspects of this liaison are not concluded at the time of writing.

The southern part of Area 1 has been subject to mineral extraction and restoration. The land is recorded in Landmark data as "EA historic landfill polygon" and "LA recorded landfill site". If the restoration material can be demonstrated to comprise overburden and interburden from the mineral extraction activity, excavation arising generated from that area will be excluded from the scope of waste. In that case, the reuse of such material will be managed under the Definition of Waste Development Industry Code of Practice (DoWCoP) in order to maintain an auditable record of the materials use within the earthworks. If the non-waste status of such material cannot be demonstrated / agreed, the arisings would be managed as waste. The local EA team has been provided with evidence to support non-landfill history of the southern part of Area 1 and the information has been passed forward to the EA team responsible for maintaining the historic landfill dataset with a request that the record is removed.

Natural soils and Made Ground will arise from excavation into the northern part of Area 1 – i.e. from land outside the historic mineral workings. Whilst natural soils excavated and able to be used in construction on the same site are excluded from the scope of waste, their use in earthworks on this scheme would be managed under the DoWCoP, as would the use of Made Ground.

The arisings from excavation into the historic landfill in Area 2 will be waste. The arisings will be treated under mobile treatment EP and the useful products of treatment will retain their waste label until their permanent deposit into earthworks, regulated by waste recovery EP. For the avoidance of doubt, the treatment will not be regulated by the site-based waste recovery EP.

Due to the unsettled status of the material to be cut from the mineral restoration area in Area 1, the waste recovery EP will include both bunds on Area 2. The permitted area boundary is limited to the areas occupied by landscape bunds LS1 and LS2 and is shown on plan "Area 2 Bunds Waste Recovery Area Boundary") (D-ESSD1C). The boundary for Area 2 is shown on plan "Site Location Plan" (D-ESSD1B).

1.3 Report Structure and Scope

The EP application requires a GRA. This has been developed using relevant EA guidance,[1] Any sections that are not applicable to the activity have been included for completeness. With an explanation of why they are not relevant.

The conceptual model in its entirety is included in Environmental Setting and Site Design report (ESSD) (RAD-WAT-A2EX-XX-RP-I-0028) which should be read in conjunction with this document. A summary of the conceptual site model (CSM) with a focus on ground gas is included within this document.

Technical information prepared for the SRFI Development Area has been utilised where appropriate.

[1] https://www.gov.uk/government/publications/management-of-landfill-gas-lftgn-03 (accessed 30/05/2023).

Including but not limited to that prepared for:

- the planning applications for the scheme;
- documents required to fulfil planning conditions (e.g., Construction Environmental Management Plan (CEMP);
- data and analysis from ground investigation;
- ground gas monitoring data from previous investigations (Capita in 2016 and MJ Carter Associates between 1993 and 1997);
- landfill waste classification analysis; and
- specification for waste suitable for use in the earthworks.

The applicant's general and environmental management policies and procedures are in place for the SRFI construction site and will be applied as appropriate to the permitted activities. The applicant's documents referred to are included elsewhere in the application bundle.

The GRA will form part of the Environmental Management System (EMS) to be operated by the applicant for the lifetime of the EP. A copy of the GRA and EMS will be kept in the VFL site office.

Plans and drawings have been prepared are presented in the "ESSD drawings and information bundle".

1.4 Limitations and Constraints

Waterman has endeavoured to assess all information provided to them during the preparation of this document but makes no guarantees or warranties as to the accuracy or completeness of this information.

The conclusions resulting from this report are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

2. Conceptual Site Model - Landfill Gas

2.1 Ground Gas Risk

As identified throughout available guidance including CL:AIRE 2012 RB17[2], CIRIA C665, 2007[3], NHBC 2023[4] documents ground gases only pose a risk when the following can be satisfied;

- An accumulation of a large volume of gas in the ground in or near the receptor (source).
- A pathway that allows gas to migrate through and/or out of the ground into a building or other structure sufficiently quickly to allow it to build up inside (pathway).
- A confined space within the building or structure where gas can build up to unacceptable levels (receptor).

In order for there to be a risk from ground gases a source – pathway – receptor linkage needs to be present. This requires a sufficient quantity of gas to pose a hazard and one or more pathways by which it may cause significant harm to people. For sustained gas migration to occur gas must be replenished at the source to negate the effects of attenuating factors such as oxidation of the methane/carbon dioxide to oxygen in the aerobic zone or low permeability soils decreasing migration potential. Therefore, sustained high levels of gas generation are required for ground gas to migrate via advective or diffusive flow and cause high ground gas concentrations at the surface/within built structures. Even where sustained high levels of ground gas generation a permeable pathway through which ground gas can migrate through is required.

Critically it is the volume of ground gas which is the principal factor which should be considered rather than the ground gas concentration, measured at the monitoring well, which is commonly mistaken as posing a risk. The assessment of ground gas volume is based on a review of both ground gas flow data and ground gas concentration data. A risk will only be existent where sufficient flow in addition to high gas concentrations is present. Assessment of the risk based solely on gas concentrations is an outdated and incorrect methodology in determining whether a possible ground gas source poses a risk. A high gas concentration present without the ability to be emitted at the surface/receptor would not pose a risk.

In evaluating whether a ground gas risk is present where a potentially significant ground gas source is present, consideration of how and whether that ground gas could migrate from the source and theoretically impact a receptor requires consideration. Where relatively impermeable soils are present between a source and receptor the lateral migration of ground gas will be heavily restricted. In material deposits above ground a below ground pathway for the migration of ground gas is absent with gases being dispersed to atmosphere. Ground gases preferentially migrate vertically in the absence of a confining impermeable layer such as concrete hardstanding or cohesive deposits, where the impermeable layer is absent the lateral migration of ground gases will be limited.

2.2 Sources

Potential ground gas sources considered are as follows:

- Existing landfill waste remaining beneath part of the landscape bunds (LS1 and LS2).
  - Existing landfill waste will remain beneath the landscape bunds and following construction of the bunds ground gas currently residing in the void space of the landfill waste may be displaced due to the increase loading applied through bund construction. Noting the bunds will be built over a period of time such the loading will be similarly phased.
- Recovered waste used to construct the landscape bund (LS1 and LS2).

[2] CLAIRE, November 2012, A Pragmatic Approach to Ground Gas Risk Assessment, RB17
[3] CIRIA, December 2007, C665: Assessing Risks Posed by Hazardous Ground Gases to Buildings,
[4] NHBC, May 2023, Hazardous Ground Gas – An Essential Guide for Housebuilders

- Treated waste from landfill waste excavated to create the rail chord embankment.
- Waste comprising restoration material/Made Ground and topsoil from Area 1 and Area 2.
- Natural material from Area 1 and Area 2.

A detailed review of the identified ground gas sources plausibility is included below.

Existing landfill remaining beneath landscape bund (LS1 and LS2)

Area 2 consisted of undeveloped, assumed agricultural land, from at least 1883. This land was later subjected to sand and gravel extraction in the 1960's and 1970's, before being infilled under two separate landfill authorisations. Both waste licences were surrendered in the 1980's. Landfill 78/48 was permitted to receive inert, commercial, and household waste between 1978 and 1981, and Landfill 77/20 was permitted to receive inert, commercial, and household, domestic putrescible solid, non-putrescible and non-hazardous solid, rubble and excavated spoil between 1954 and 1983. The waste material has therefore remained in-situ for least 40 years, with the oldest material 69 years old.

Ground investigations were carried out in Area 2 in 2016 (Capita) and 2022 (Waterman) to understand Area 2's ground model and to help characterise the landfill waste.

Characteristics of the landfill waste are detailed in the Waterman 2023 Ground Conditions Report (RAD-WAT-A2EX-XX-RP-I-0003) and can be described as 'domestic waste comprising glass, plastic, polystyrene, ceramic, metal, cables, textiles, paper, sponges, tin, newspaper (dated 1980), fragments of paper, cardboard, and book (1979) in a dark greyish brown and black sandy gravelly clay matrix. Construction-type waste including fragments of brick and masonry, concrete, and tarmacadam were also encountered. Fragments of wood, rubber, black and white plastic sheeting, electrical wires, ripped nylon sheet, wood chippings, rope, clumps of straw were also present.'

Figure 1: Typical landfill waste on excavation

Ground gas monitoring was undertaken by Capita on four occasions between May and July 2016 and by MJ Carter Associates on six separate visits between 1993 and 1997. The ground gas monitoring results have been reviewed to identify those unrepresentative of the ground gas regime and not impacted by other factors such as groundwater.

Ground gas results recorded during the MJ Carter ground gas monitoring completed between 1993 and 1997 identified methane above the limit in 10No. locations with a maximum concentration of 32.7%., carbon dioxide was generally reported <1% with 2No locations recording carbon dioxide at 6% and 10.9%. Ground gas flow rates were not reported. The monitoring was completed in 11No. wells. The ground conditions and response zones of the wells monitored are not known, therefore whilst the results have been incorporated into the assessment of the Site's ground gas regime the absence of this information has been accounted in utilising the MJ Carter ground gas monitoring results in assessing the materials ground gas generational potential.

A summary of the representative[5] Capita 2016 ground gas monitoring results is included in Table 1.

[5] Excluding monitoring wells installed with response zones which are unduly impacted by groundwater or flooded causing them to be unrepresentative of the ground gas regime. Monitoring wells installed at depth in natural deposits have also been excluded.

Table 1: Representative ground gas results

Borehole	Response Zone (mbgl)	Methane (%)	Carbon Dioxide (%)	Flow (l/hr)
BH52 (shallow)	1.0 – 5.0 Landfill	20.5, 11.6	22.4, 16.0	<0.1
BH54 (shallow)	1.0 – 6.0 Landfill	10.7, 54.6	3.2, 30.1	<0.1
BH55	2.0 – 15.0 Kesgrave Gravels, Chalk	<0.1	3.7, 5.3	<0.1
BH56 (shallow)	2.0 – 6.0 Kesgrave Gravels	<0.1	2.2, 0.2	<0.1
BH58 (shallow)	2.0 – 6.0 Landfill	29.7, 40.6	1.6, 26.8	<0.1, 0.1
BH58A	1.0 – 5.5 Landfill	57.6	19.6	0.1

Ground gas monitoring in representative wells outside the landfill waste and within the wider Radlett Area 2 as part of the 016 Capita ground investigation recorded methane <0.1%, flow rate <0.1l/hr, and peak steady carbon dioxide 0.2%, 2.2%, 3.7%, 5.3%.

The ground gas monitoring results are consistent with the age of the waste material in 2016 in which a large proportion of the labile organic matter has been lost. Whilst high ground gas concentrations have been recorded flow rates are low being either below the equipment's detection limit or marginally above. The absence of measurable sustained gas flow rates is typical of material in which only a low volume of organic content is present. In these situations, the organic material is degraded at such low rates they are not emitted at quantities or rates sufficient to sustain migration and pose a risk to receptors. With the ground gas effectively entrained in the soil matrix, and methane oxidising prior to being emitted at surface level. This coincides with the Wilson[6] 2018 guidance that after 20 years ground gas generation will have reduced significantly, and will be at residual, very low levels after 40 years. Therefore, the landfill waste in its current state is not capable of generating sufficient volumes of ground gas such that ground gas migration can take place. The absence of significant ground gas concentrations in wells installed outside the landfills is clear evidence that lateral migration of significant ground gas concentrations is not currently occurring.

Following construction of the bunds above the landfills, settlement is anticipated to occur. The settlement will result in the reduction of pore space in the waste mass as well as other soil layers beneath the bunds. The settlement may result in the temporary displacement of ground gas caused by the reduction in pore space. This displacement will occur gradually over a period of time during bund construction and will occur until an equilibrium is reached. The quantum of gas displaced is unlikely to be significant with lateral migration of the ground gas still subject to attenuation factors along the transport pathway. The construction of the bunds would not alter the gas potential of the landfill waste which is beyond its ability to generate quantities of ground gas at rates that can cause migration. It is noted the reduction in pore space through loading created through bund construction will result in a densification of the landfill waste and reduction in permeability, post bund construction a reduced ground gas risk will be present.

2.2.1 Waste to be Used to Construct the Landscape Bunds

The wastes used will all arise from earthworks (cut) at the Radlett SRFI site in and outside the historical landfills to construct the rail chord, and to construct the development platform for the proposed built

[6] https://epg-ltd.co.uk/wp-content/uploads/2019/03/paper-s-wilson-hard-copy-v2.pdf (Accessed 21/06/2023).

structures on Area 1. Waste types generated and recovered within the Area 2 bunds under the EP will be limited to:

- Treated landfill waste.
- Restoration material
  - Including Made Ground outside former landfill boundaries, landfill capping material, and site won interburden and overburden used to restore Area 1 post mineral extraction.
- Made Ground
  - Outside former landfill boundaries
- Natural material
  - Including Kesgrave Catchment Subgroup and Chalk Formation
- Topsoil

The waste will be limited to site derived non-hazardous waste which meet the chemical and physical specification. Table 2 sets out the anticipated waste EWC codes.

Table 2: Proposed waste types

EWC code	EWC description	Limitations
17 05 04	Soil and stones other than those mentioned in 17 05 03	Limited to site-derived waste meeting the chemical and physical specifications for the works.
17 09 04	Mixed construction and demolition waste other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	Limited to site-derived waste meeting the chemical and physical specifications for the works.
19 12 09	19 12 09 minerals (for example sand, stones)	Limited to site-derived waste meeting the chemical and physical specifications for the works.
19 12 12	19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	Limited to site-derived waste meeting the chemical and physical specifications for the works.

Treated landfill waste excavated to create the rail chord embankment

Excavated landfill waste is to be treated to recover the usable fraction for use in the construction of the landscape bund LS1 and LS2. Only the material which complies with a non-hazardous waste classification as assessed in accordance with WM3[7] will be used in accordance.

The excavated waste will be treated (mechanical screening and hand picking) under separate mobile treatment EP to form acceptable Class 1A or 2A materials for use in bund construction. The exact composition of the recovered waste is not known at present but will comprise a heterogenous mix of material including recovered brick, concrete, gravels, sand, silt with large fragments of organic matter removed. Post material treatment its ground gas generational potential will not be altered with the material not be capable of generating significant quantities of ground gas.

Full details of the sampling methodology, testing, and assessment of the recovered landfill waste to demonstrate compliance with a non-hazardous waste classification are detailed in the Waste Acceptance

[7] https://www.gov.uk/government/publications/waste-classification-technical-guidance (accessed 21/06/2023).

Procedures (WAP - RAD-WAT-A2EX-XX-RP-I-0034) and Earthworks Specification (RAD-WAT-A2EX-XX-SP-C-0023).

Topsoil and subsoil waste overlying and outside the landfill

Topsoil and subsoil waste material overlying the landfill waste excavated as part of constructing the rail embankment will be used in the bunds construction. Ground investigation in Area 2 confirmed this material comprises slightly gravelly, slightly sandy, clayey silt with varying quantities of rootlets and roots and occasional brick and concrete fragments were identified. The waste will be visually inspected, and anthropogenic material removed. Material containing visual and olfactory staining, visible ACM fragments, metal staining, or highly odorous will not be used in bund construction.

Waste from Area 1 comprising restoration material or made ground

As part of preparing Area 1 for development significant cut of material is required to create a level development platform (about 74m AOD). Restoration material and Made Ground will be used in landscape bund LS1 and LS2.

Historical OS map extracts indicate Area 1 comprised undeveloped agricultural land from at least 1883 to the late 1920s. Stroud Wood, covering an estimated area of about 6 to 7 hectares, was located near the centre of Area 1 until the late 1930s.

Radlett Aerodrome occupied much of Area 1 from 1929 until its closure in 1970. There is no indication any significant buildings associated with the aerodrome were situated within Area 1. The OS mapping and desktop study indicate aircraft hangers, fuel tanks and other infrastructure were predominantly located to the south, beyond what is now the M25. Some facilities including a wind tunnel were located within Area 1, in its north-western sector, with a number of small buildings indicated on a 1972 OS extract.

Mineral extraction commenced predominantly in the southern half of Area 1 in the early 1990s following planning approval for sand and gravel extraction and restoration to agriculture (planning permission ref. 5/0830-83). Mineral extraction is understood to have ceased in the late 1990s and restoration to a suitable level for agricultural land use was established by using site-won overburden and interburden which was completed in the early 2000s.

Historically the northern section of Area 1 outside of the gravel extraction area remained as agricultural land with Hedges Farm from the 1883 OS Map remaining in its present-day location. Part of the Radlett Aerodrome runway was present in the northeast portion which was subsequently restored to agricultural in 2000s.

A previous ground investigation was undertaken in Area 1 by Capita in 2016 (CS-070751-PE-16-1347-R). A review of exploratory hole logs indicates the restored and made ground soils typically comprised re-worked natural soils generated from historical site activities (i.e. quarrying and, prior to that, the site's use as an aerodrome). Their composition was variable, comprising soft gravelly clay, clay sand and clayey / sandy gravel. An organic fraction was frequently observed in thin horizons (often described as 'organic patches'), potentially associated with remnant topsoil which became buried and intermixed into underlying layers during quarry infilling. Infrequent anthropogenic material including brick and tile fragments were observed locally in the upper parts of the Made Ground, as well as occasional clasts of concrete and/or macadam.

Laboratory analysis of 12No. samples from the Area 1 cut area recorded the Total Organic Content (TOC) ranged from <0.1 – 2.0% (average 0.9%). The average result falls below the ≤1.0% TOC concentration identified in CL:AIRE RB17[2] (2012) for made ground in place for >20 years and would be considered CS1 (very low risk).

A review of ground gas monitoring data in the portion subject to cut on Area 1 were assessed and showed the following:

- No significant concentrations of methane were present (<0.1% in all locations);
- A marginally 'elevated' CO2 concentration (>5%) was recorded at one location only – BH33 (5.8%) on one occasion.
- Gas flow rates were predominantly very low (<1.0 l/hr), with moderate rates detected at BH21 (maximum 4.4 l/hr) and BH32 (maximum 4.2 l/hr) only, and on one occasion each, with the other occasions recording very low flow rates (<1.0 l/hr).

The absence of consistent elevated gas concentrations and consistently low flow rates identifies the material as not being a significant ground gas generating source.

Material containing visual and olfactory staining, visible ACM fragments, metal staining, or highly odorous will not be re-used in bund construction.

Natural cut material in Area 1

Natural material cut from Area 1 will be used to construct a portion of the bunds in Area 2. Natural material used will comprise the Lowestoft Formation and potentially the Kesgrave Gravel Formation which underlies the Lowestoft Formation. The natural material does not represent a significant ground gas generating material.

2.3 Receptors

Potential receptors identified in Area 2 include:

- Construction workers on-site;
- Future site users in Area 1;
- Built structures on Area 1; and
- Global climate.

The closest off-site residents are located 300m northeast of bunds LS1 and LS2. Given this distance, the landfill waste age beneath the bunds, and the waste to be used to construct the bunds there is no plausible risk to these receptors and therefore they are excluded from further assessment.

The human receptors including construction and maintenance workers, and future site users have an acute risk and have the highest sensitivity to ground gas. Post development completion the risk to construction workers and maintenance workers from ground gas will require managing through correct working practices and appropriate Personal Protective Equipment (PPE) as required.

The waste to be used to construct the bunds has a low ground gas generational potential, the release of significant gas emissions is therefore unlikely removing Global Climate as a plausible receptor which shall not be considered further in this assessment.

2.4 Pathways

Potential pathways for ground gas will be considered from the sources highlighted in Section 2.2 to receptors highlighted in Section 2.3 and are defined as follows:

- Existing landfill waste remaining beneath the new landscape bunds
  - Compression of ground from the construction of overlying landscape bunds may cause the migration of ground gases in the landfill waste to the immediate surrounding area.
  - Accumulation of ground gas beneath an impermeable overlying soil or constructed paving which is transported to surrounding area via an impermeable soil tunnel or maintenance pathway.

- New drainage culverts are to be constructed as part of the bund construction to convey bund drainage water away from the bunds. The bund drainage details are presented on plans D-ESSD6A – 6D.
- Collection of ground gas in excavations into which construction or maintenance staff need to enter.

- Waste Used to Construct the Landscape Bunds
  - The bunds will be above ground, any ground gas generated by residual material organic matter in the waste will be dispersed in the atmosphere prior to impacting identified receptors.

2.4.1 Existing Landfill to remain beneath landscape bund

Lateral migration into the immediate area through the surrounding soil matrix

The bund construction will apply additional loading to the underlying landfill waste which may result in the temporary displacement of ground gas caused by a reduction in pore space. The additional loading will occur over the period of time during bund construction with the overall volume of ground gas being produced through reduction in pore space unlikely to be significant at any moment in time.

For sustained gas migration to occur gas must be replenished at the source to negate the effects of attenuating factors such as oxidation of the methane in the aerobic zone or low permeability soils decreasing the migration potential. Therefore, sustained high levels of gas generation is required for ground gas to migrate via advective or diffusive flow and cause high ground gas concentrations at the surface. The bunds construction will not change the generation potential of the underlying landfill waste which is what is needed to create a positive flow sufficient to consistently release a volume of ground gas capable of impacting human receptors in an open-air environment.

Ground gases preferentially migrate vertically. A continuous impermeable layer is required to enable the lateral migration of ground gases a large distance from the source where a significant ground gas generating source is present. Ground investigations on-site and in the surrounding area identify a continuous impermeable layer capable of enabling the lateral migration of ground gas a significant distance as being limited with ground gas preferentially migrating vertically.

Lateral migration to the surrounding area within an impermeable channel

As part of bunds construction landscape bund drainage will be provided. The drainage infrastructure will comprise;

- A series of perforated land drainage pipes lying in trenches, at the base of the landscape bund, between 0.6 to 1.0m deep backfilled with stone to achieve a void ratio of 0.66 or greater.
- Open swales sizes vary across the site ranging from 1-2m wide and 0.5-1.3m deep with slope sides at a ratio of 1:3 or 1:2 in some sections where swale width is restricted.
- A culvert from the northern side of LS2 to convey water to a drainage ditch adjacent to the east of Area 2
- A culvert from the east side of the MML to the drainage ditch adjacent to the east of Area 2.

The drainage features and types are shown on plans D-ESSD6A – 6D.

The stone filled ditches with the perforated land drainage pipes and swales are “open to air” features and therefore will not allow ground gas to collect nor migrate along their length.

The culvert conveying water collected from the LS2 bundto the drainage ditch adjacent to the east of Area 2 is open at both sides allowing the feature to be vented to open air preventing the accumulation of ground gas.

Likewise, the culvert starting at the east side of the MML that passes beneath bund LS1 is open at both ends and has open connections to the bund drainage swales at the east and west sides of the landscape bunds. Covers to manhole access chambers will be vented to prevent an accumulation of ground gas in these features. Therefore, no part of the drainage network serving the bunds forms a sealed network leading to a receptor, hence a complete pathway via the drainage network is absent.

In summary the following drainage network attributes prevent the drainage network from being a complete pathway for the migration of ground gas.

- Drainage swales at the toe of the bunds are open to air preventing the accumulation of ground gas
- Drainage filter trenches comprise stone filled lined trenches with perforated pipes varying in diameter from 0.15m to 0.25m. The perforated and pipes coarse stone will prevent the drainage features accumulating ground gas and acting as an impermeable pathway
- Culverts are open ended and are connected to the bund drainage via open head wall connections, manhole access covers will be vented. This will prevent the culvert acting as pathways. The open ends of the culverts are not located near receptors.

Collection of ground gases in excavations

Excavation within the previous extents of the historical landfill for the installation and maintenance of drainage services as well as any future excavations following the completion of the development has the potential to collect ground gases over the lifecycle of the excavation.

Excavations produce a void space and thus a pressure gradient pathway whereby ground gases from the pore space in the surrounding soil could ingress from the sides of the excavation. Heavier ground gases such as CO_2 sink to the base of an excavation which can be compounded by high pressure, low turbulence weather systems restricting air flow into the trench and thus reducing mixing with the open air. The increased concentration of CO_2 within these excavations would pose a risk to people entering the excavation.

Entry into the drainage network or excavations as part of maintenance and construction activities will be removed through effective mitigation measures including being carried out in line with an activity specific risk assessment and method statement in accordance with Confined Space Entry Regulations 1997.

2.5 Conceptual Model Conclusions

Loading of Landfill Waste Retained Underlying the Landscape Bunds

Landfill waste underlying the bunds will be loaded resulting in the displacement of ground gas within the pore space. The displacement will be spread over the period of time bunds are constructed such that a limited volume of ground gas will be produced. The gas displaced will be subject to limited lateral migration due to the several attenuation factors including the absence of a continuous impermeable layer overlying the area between the historic landfills and the sensitive receptors (Area 1 proposed Development). The bund construction would also not alter the landfill wastes ground gas generational potential which from previous ground investigations and desk based assessment has been identified as Low. Generation of sustained ground gas will therefore be absent. The conceptual model for the bund construction on existing retained landfill waste therefore identifies the risk as low with the pollutant linkage broken through source and pathway removal. Notwithstanding the assessment ground gas monitoring will be undertaken between the landscape bunds and Area 1 to monitor ground gas concentrations and flow rates to determine whether a significant risk is being created.

Waste Used in Landscape Bunds

Wastes to be used in landscape bund and their associated ground gas generational potential include the following:

- Treated landfill waste – Low ground gas generational potential as evidenced by ground gas monitoring results, and age of material.
- Restoration material, and Made Ground – Low ground gas generation potential in low labile organic matter content.
- Natural material – Low ground gas generational potential.

The treated landfill waste will form only a small portion of the landscape bunds.

The landscape bunds will be located above ground, where if ground gases are generated, they will disperse and dilute within the atmosphere. A plausible pathway to identified receptors is absent and a low risk is assigned to waste used to construct the landscape bunds.

A significant impact on the global climate has not been identified given the low ground gas generational potential of the waste.

A potentially significant risk to construction workers and maintenance workers has been identified which will require management through the application of appropriate health and safety measures and wearing of PPE as required. All works will also require adherence to the 1997 Confined Space Regulations.

Preferential Pathways

Potential preferential pathways identified include drainage swales, drainage filter trenches and culverts. A review identifies the pathways either open to air, open ended and/or vented, and they have therefore been discounted as preferential pathways.

3. Landfill Gas Risk Assessment

3.1 The Nature of the Landfill Gas Risk Assessment

The landscape bunds in Area 2 will comprise be constructed over existing landfill waste using wastes from Area 1 and Area 2. A new potential ground gas generating source will not be introduced to Area 2. As evidenced by the assessment of the waste to be used which has a low ground gas generation potential and will be placed above the current ground surface therefore no pathway exists for this ground gas to accumulate and migrate to a receptor.

The bunds will be built on existing landfill waste that is in excess of 40 years old which significantly limits its ability to generate ground gas. The ground gas CSM has confirmed that while the construction of the bunds may cause the displacement of ground gas from the waste material to adjacent soil, pathways do not exist for the displaced ground gas to migrate to identified receptors.

The assessment has demonstrated existing and proposed drainage networks will not form a complete pathway capable of allowing ground gas to migrate to receptors.

During the construction and following maintenance of the Area 2 drainage network, construction and maintenance staff may need to enter excavations or parts of the drainage network. Entry into the drainage network or excavations as part of maintenance and construction activities will be carried out in line with an activity specific risk assessment and method statement in accordance with Confined Space Entry Regulations 1997.

3.2 The Proposed Assessment Scenarios

3.2.1 Lifecycle Phases

The construction of LS1 will occur over three earthworks seasons the construction of LS2 will occur over one earthworks season.

Waste to construct the bunds will be placed and compacted in line with the Earthworks Specification (RAD-WAT-A2EX-XX-SP-C-0023). Waste will also be confirmed to have passed the chemical specification as detailed in the WAP. Material with visual and olfactory signs of contamination will not be used in bund construction.

The CSM has demonstrated a complete pollutant linkage resulting from landscape bund construction, or in the permanent state is absent therefore further detailed risk assessment is not required.

Risk assessment regarding confined space entry required to excavations or the drainage network during construction and maintenance will be carried out in accordance with task specific risk assessments in compliance with Confined Space Entry Regulations 1997. During construction this will be managed by the VolkerFitzpatrick Limited the Principal Contractor, following completion of the development and during it operation this will be controlled by SEGRO Radlett Ltd.

3.3 Accidents and their Consequences

The construction of the bunds presents a low ground gas risk.

The use of visually or olfactorily contaminated material is excluded by the WAP. This will primarily be controlled through visual/olfactory screening at excavation, a second check will be carried out during placement of the waste.

If previously unidentified contaminated material or unchartered landfill waste is encountered the following steps should be taken:

- Works should cease in the affected area and be cordoned off;

- A specialist should be consulted, who will advise on the next steps specific to the contamination encountered and prepare a method statement detailing these measures. The details of the additional remedial measures, where required, will be shared and agreed with the regulatory authorities prior to implementation;
- Soils should be sampled either in-situ (and left undisturbed whilst the samples are tested) if safe to do so or the soils should be excavated and stockpiled separately in an appropriate manner;
- If the material comprises landfill waste, it will be excavated and either sent for offsite disposal or for treatment to recover the usable fraction.
- Measures should be taken to restrict dust generation and surface water run-off; and
- On receipt of the results, if deemed necessary the soils should be remediated and/or disposed off-site to a suitably licensed facility.

The likelihood of considerable amounts of visual or olfactory contaminated material inadvertently being used in the bund construction such that additional ground gas risk is posed is low particularly given the construction of the bunds will be above ground.

Entry into excavations and the drainage network will be controlled by risk assessment and appropriate method statement in accordance with the Confined Space Entry Regulation 1997.

3.4 The Generated Gases to be Modelled

This section is not applicable. No modelling is proposed given the low potential for ground gas generation.

3.5 Numerical Modelling

3.5.1 Justification for Modelling Approach and Software

This section is not applicable. No modelling is proposed given the low potential for ground gas generation.

3.5.2 Model Parameterisation

This section is not applicable. No modelling is proposed given the low potential for ground gas generation.

3.5.3 Sensitivity Analysis

This section is not applicable. No modelling is proposed given the low potential for ground gas generation.

3.5.4 Model Validation

This section is not applicable. No modelling is proposed given the low potential for ground gas generation.

3.6 Risks to the Environment and Human Health

3.6.1 Landfill Gas Emissions

As identified in Section 2 construction of the landscape bunds present a low ground gas risk due to the source not being capable of generating sufficient ground gas, and being constructed above ground.

Also a complete source receptor linkage will not be created by completion of the bund construction and

associated bund drainage.

There is the potential for ground gas to accumulate locally in excavations or newly installed drainage infrastructure in the vicinity of the landfill waste. This ground gas would migrate to the excavation or drainage feature as a result of disturbance of soil and the creation of a local void space and subsequent concentration gradient. Its accumulation would not be due to ground gas migration which is being driven by the degradation of organic material.

Entry into excavations and the drainage network during construction and maintenance will be controlled by risk assessment and appropriate method statement in accordance with the Confined Space Entry Regulation 1997.

3.6.2 Sub-surface Migration

For sustained ground gas migration to occur and to pose a risk to receptors a significant volume of ground gas is required to sustain the ground gas migration and replace the gas that has migrated. As evidenced in Section 2 the wastes to be used in landscape bunds construction and the underlying existing landfill waste has a low ground gas generation potential and a complete source receptor pathway will not be created by the construction of the bunds and drainage.

The sub-surface migration (lateral and vertical) of ground gas will be inhibited by the following aspects:

- The landscape bunds waste following deposition will be above ground and any ground gas generated will not migrate laterally through adjacent ground.
- Lateral migration capable of impacting sensitive receptors would require an unbroken impermeable layer capable of confining the ground gas for the required distance. Waterman's GI (RAD-WAT-A2EX-XX-RP-I-0003) confirms a layer does not exist nor will one be constructed as part of the development.

Some ground gas currently residing in soil pore space underlying the proposed bund locations may be displaced horizontally during the bund construction however this is not due to gas generation as a result of organic matter degradation. A continuous emission of ground gas required to enable substantial and sustained lateral ground gas migration is therefore absent.

Given the above a negligible risk of ground gas migration and impact of receptors will exist.

3.6.3 Vegetation Stress

Evidence of vegetation stress is not present. This confirms the absence of ground gas generation such considerable volumes of ground are migrating vertically to the ground surface. As part of bund construction some ground gas may be displaced laterally potentially leading to local vegetative stress. However, given there is currently no evidence of vegetation stress and any volume of gas displaced will be less than the total volume at the source, vegetative stress if it does occur is expected to be temporary in nature and local to the edges of the bunds.

3.6.4 Atmospheric Dispersion and Odour

Odours are currently not present on Area 2. Significant ground gas emissions including odour are not expected given the low ground gas generation potential of the landscape bunds source material. Given the age of the current landfill waste it no longer capable of generating such volumes of ground gas that an odour would be noted at surface. Gas management plant will therefore not be required, rendering this section as not applicable.

During construction of the bunds the generation of signficant odour emissions are not expected, however where encountered and odour management plan will be implemented.

3.6.5 Exposure

Significant ground gas emissions including odour are not expected given the low ground gas generation potential of the landscape bunds source waste and the age of the current landfill waste. Also a current source receptor pathway does not exist.

Entry into excavations and the drainage network during construction and maintenance will be controlled by risk assessment and appropriate method statement in accordance with the Confined Space Entry Regulation 1997.

3.6.6 Global Atmospheric Impact

Significant ground gas emissions from the landscape bund waste will not occur due to the wastes low ground gas generation potential. Displaced ground gas from the existing landfill underlying the bunds may migrate to surface however given the age of the landfill waste, and its potential to generate significant volumes of ground gas is past, the volumes emitted are considered to not to pose a risk to the global atmosphere.

Where residual methane is present the gas generation rates are likely to be such the methane will oxidise to carbon dioxide and water vapour in the aerobic sub-surface environment prior to emission at surface level, further restricting the likely global atmospheric impact.

3.7 Landscape Bunds Gas Completion Criteria

As identified in Section 2 the waste to be recovered by use in landscape bund construction and the existing landfill waste have low ground gas generation potential. Also, a complete source receptor linkage will not be present following completion of the bunds.

The construction of the landscape bunds will therefore not pose a ground gas risk (pressure driven or diffusive flow) to receptors at any point in the waste life cycle and would therefore be considered as being 'completed' immediately after its deposition.

Two sets of completion criteria are provided in the regulatory guidance[10];

- Criteria 1 – Gas concentration
  - Methane concentration within the waste mass is less than or equal to 1.5%v/v
  - Carbon dioxide concentration within the waste mass is less than or equal to 5%v/v
- Criteria 2 – Flow Monitoring
  - The site will meet gas completion criteria where the maximum landfill gas flow rate (Qhgs) as defined by BS8485:2015:
    - In in-waste monitoring boreholes is less than 0.7l/hr and
    - Recorded in any individual in waste borehole less than 70l/hr

Both Criteria 1 and Criteria 2 relate to boreholes installed within the waste. As assessed in this GRA the landscape bunds will be located above ground, where ground gases are generated, they will disperse and dilute within the atmosphere. A plausible pathway to identified receptors are absent and a low risk is assigned to waste used to construct the landscape bunds.

The monitoring detailed in the Monitoring and CQA Plan (RAD-WAT-A2EX-XX-RP-I-0035) includes monitoring wells installed between the landscape bunds and the closest receptor identified as the future warehouses on Area 1. The purpose of the monitoring will be to establish whether the construction of the

[10] Environment Agency, March 2022, Landfill and Deposit for Recovery: Aftercare and Permit Surrender, Landfill and deposit for recovery: aftercare and permit surrender - GOV.UK (www.gov.uk) Accessed 13/07/2023)

landscape bund results in the increased lateral migration of ground gases from the landfill waste underlying the landscape bunds.

The current ground gas regime on Area 1 is set at Characteristic Situation 1 (CS1) in which ground gas protection measures would not be required. The completion criteria will therefore be set as a landfill gas flow rate of 0.07l/hr which is the Gas Screening Value (GSV) for which a Characteristic Situation 2 (CS2) classification should be considered. The completion criteria in addition will allow for further and detailed assessment to understand whether based on ground gas concentrations and flow rates a risk exists to developments on Area 1 such ground gas protection measures consistent with a CS2 classification would be required.

4. Landscape bunds Gas Management Plan

4.1 Control Measures

Gas control measures are not required given the landscape bunds waste's low ground gas generation potential.

4.2 Monitoring and Sampling Plan

The monitoring and sampling plan is included in Monitoring Plan and CQA Plan (RAD-WAT-A2EX-XX-RP-I-0035).

5. Conclusions

Ground gas will be generated from two sources:

- Existing landfill waste will remain beneath the landscape bunds and following construction of the bunds ground gas currently residing in the void space of the landfill waste may be displaced due to the squeezing effect of the new bunds.
- Recovered waste used to construct the bunds, comprising treated landfill waste excavated to create the rail chord, restoration material/made ground and topsoil from Area 1 and Area 2, and natural material from Area 1 and Area 2.

During and post completion of the landscape bunds, significant volumes of ground gas will not be produced given the negligible ground gas generation potential of the landfill waste. The ground gas generation potential will decrease further for the recovered waste during its excavation and stockpiling in which the residual organic matter will be exposed to aerobic conditions catalysing its degradation.

Human receptors including construction and maintenance, and future site users have an acute risk and have the highest sensitivity to ground gas. This is particularly true for workers entering excavation within Area 2.

The pathways for ground gas to human receptors have been assessed in Section 2.4 which concluded pathways were not plausible given the low gas generation potential of the waste in the permitted area and in the underlying historic landfills. The only exception is to construction and maintenance staff entering excavation drainage infrastructure. Entry into excavations and the drainage network during construction and maintenance will be controlled by risk assessment and appropriate method statement in accordance with the Confined Space Entry Regulation 1997.

Therefore, ground gas control measures to control the accumulation of ground gases would not be required and there will be no change to the ground gas regime.

Confirmatory monitoring before, during and post construction of the bunds will confirm the waste has a negligible ground gas generation potential, no plausible pathway for the ground gas to migrate to potential receptors, and low risk receptors. The monitoring will also demonstrate the bund construction will not alter the ground gas regime in the underlying landfill waste. This confirmatory monitoring is a permitting and planning requirement.

5.1 Compliance with the Landfill Directive 1999

The landscape bund material will be used under a waste recovery EP, compliance with the 1999 Landfill Directive would therefore not be applicable.

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