PT-CE Ltd

PODE HOLE QUARRY

Gas Risk Assessment

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1 INTRODUCTION

1.1 TERMS OF REFERENCE

This Gas Risk Assessment (GRA) Report has been prepared by WSP UK Ltd (WSP), on behalf of PT-CE Ltd (PT-CE) in support of its application for an Environmental Permit (EP) for waste Deposit for Recovery (DfR) (hereafter referred to as the 'permit application') for Pode Hole Quarry, The Causeway, Thorney, Peterborough PE6 0QH (hereafter referred to as the 'Site').

This report should be read in conjunction with the Environmental Setting and Installation Design (ESID) Report (Report ref. UK0038843_2142-WSP-RP-GW-0002).

1.2 BACKGROUND

The Site is located 1.85 km west of the village of Thorney and 5 km west of Peterborough. The A47 ('The Causeway') runs 460 m to the north of the Site and Willow Hall Lane runs along the western boundary of the Site. The Site extends to approximately 68.5 hectares (Ha).

The Site contains a void of approximately 1.8 million m^3 as a result of the mineral extraction of sand and gravel. The proposed DfR operation at the Site will be a regulated facility which is classified as a Waste Operation under the Environmental Permitting (England and Wales) Regulations (2016). Deposit for recovery uses waste material instead of non-waste material to perform a function, in this case quarry restoration. This allows the non-waste to be available for other uses. The Site will only accept waste classified as inert under waste acceptance procedures. A detailed description of the Site and installation development are provided in the ESID.

1.3 REPORT STRUCTURE

This report presents the Gas Assessment for the Pode Hole Quarry DfR as follows:

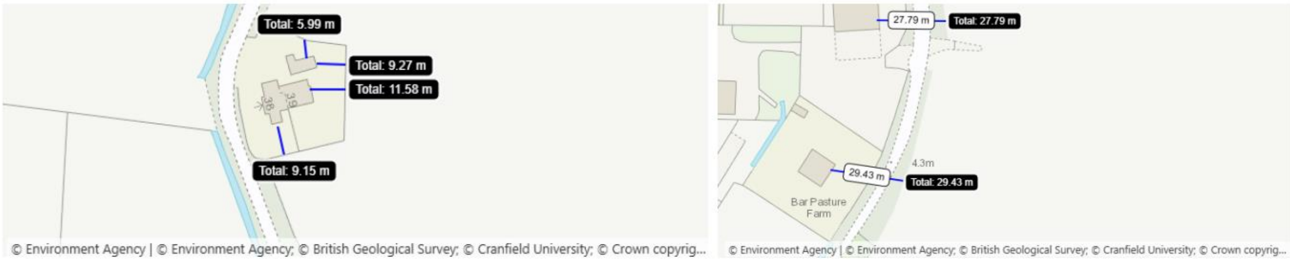
- Section 2 presents the conceptual model and risk screening;
- Section 3 presents the gas monitoring plan;
- Section 4 presents the gas action plan; and
- Section 5 presents the gas completion criteria.

2 CONCEPTUAL MODEL

2.1 INTRODUCTION

There are two properties in close proximity to the future DfR waste mass (<20 m, Figure 2-1).

Figure 2-1 - Sensitive Receptors at Potential Risk of Lateral Gas Migration



While the infilled waste to be accepted is inert, it includes waste code 19 12 12 which refers to wastes (including mixtures of materials) from mechanical treatment of waste. Waste with this code is considered by the Environment Agency (EA) to be of higher risk of containing non-conforming materials[1]. Such materials may include biodegradable content leading to gas generation in the waste mass. To reduce this risk the Site-specific Waste Acceptance Procedures[2] (WAP) restricts the accepted waste under 19 12 12 to crushed bricks, tiles, concrete and ceramics only. It explicitly stipulates that the waste can "*not include fines from treatment of any non-hazardous waste or gypsum from recovered plasterboard*". Thereby any biodegradable content and source of potential gas production is excluded from 19 12 12 (further details are provided Section 2.3).

Subsurface lateral gas migration from a landfill is driven by concentration differentials (diffusive flow according to Fick's Law), or pressure differentials (advective flow), or both. Gas may move through the permeable sand and gravel deposits surrounding the Site. The concern is the potential accumulation of landfill gas in confined spaces near to the Site such as building basements, manholes, tunnels or even poorly ventilated spaces below portable buildings, which may lead to an explosive or asphyxiant hazard.

Methane, a main constituent of landfill gas, is flammable and forms explosive mixtures with air when present between the concentration limits of 4.4 %v/v (Lower Explosive Limit, LEL) and 16.5 %v/v (Upper Explosive Limit, UEL) at 20°C and 1 atmosphere pressure. The migration and dilution of landfill gas with air can therefore result in the formation of highly explosive atmospheres. The accumulation of landfill gas in enclosed spaces can also pose a direct risk to humans due to asphyxia. This may be caused when the oxygen content of the atmosphere in the breathing zone is reduced below 10 %v/v by admixture with migrating gas. The lateral sub-surface migration of gas can further cause damage to vegetation on adjacent land and crop die-back (chlorosis).

[1] Pre application advice – Enhanced service. Pre-application reference: EPR/JP3220LG/P001 (11/03/2025).

[2] Waste Recovery Plan: Version 2 (October 2019) - Appendix 2: Waste Acceptance Procedures

2.2 ASSESSMENT APPROACH

The assessment approach will identify the potential risks associated with lateral landfill gas migration from the Site. It will be undertaken following a source – pathway – receptor approach. A risk is assumed to exist if a viable link between all three components is likely to be present at the Site and can be summarised as follows:

- The source is any gas generated from the waste's biodegradable fraction (Section 2.3);
- The pathways are the subsurface routes linking the source and receptors (Section 2.4); and
- The receptors which may comprise service ducts, nearby dwellings or other structures in which landfill gas could accumulate and pose a risk to users/occupants or the surrounding vegetation which could be affected by the presence of gases in the root zone (Section 2.5).

2.3 SOURCE

The Waste Recovery Plan has estimated that 2,700,000 tonnes of material will be imported to Site, based on an estimated waste density of 1.5 tonnes/m^3 over a 10-year period. Only suitable inert restoration materials will be imported for the purpose of the quarry restoration to comply with the requirements of DfR. The waste codes proposed for the Site, with additional restrictions, are shown in Table 2-1 of the ESID.

The listed waste codes restrict the accepted waste under 19 12 12 to crushed bricks, tiles, concrete and ceramics only. The waste acceptance procedures within the WRP[3] explicitly stipulates that the waste can "*not include fines from treatment of any non-hazardous waste or gypsum from recovered plasterboard*". Thereby any biodegradable content and source of potential gas production is excluded from 19 12 12. The waste acceptance procedures further include detail on how compliance with the stipulated waste codes and additional restrictions will be ensured, for example:

- During collection of a load, the driver will ensure that the waste type is acceptable as per instructed and match the issued Waste Transfer Note (WTN).
- Upon arrival at Site, loads not accompanied by a WTN or that do not match the description the WTN will be rejected.
- Every load is visually inspected prior to being off loaded.
- After checking the load and the associated paperwork the vehicle is directed to the offloading area for inspection and stockpiling. A Site Operative will inspect tipped loads.
- If there is a discrepancy with the load or its paperwork, then the Site Manager shall be informed immediately. If the load is not acceptable under the Environmental Permit then, if possible, it should be re-loaded onto the vehicle and rejected from site.
- If it is impossible to load a rejected load back onto the delivering vehicle the load will be put into the quarantine area. The customer will be contacted, arrangements to remove the quarantined waste will be made and a copy of the rejection form containing reasons for the rejection will be supplied.
- If arrangements for the customer to remove the waste cannot be made, PT-CE will make these arrangements themselves. Waste material in the quarantine area will be exported off Site by a licensed waste carrier to an appropriately licensed facility. If necessary, PT-CE will contact the EA regarding the rejection of the waste.

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[3] Waste Recovery Plan: Version 2 (October 2019) - Appendix 2: Waste Acceptance Procedures

Reasons for rejection of a waste load include:

- Delivery vehicle is unsuitable for site operations / conditions;
- The waste is not acceptable at the Site under the Environmental Permit;
- There is a prohibited waste within the load;
- The load is not accompanied by the correct documentation;
- The waste does not match the description on the accompanying documentation; and/or
- The waste contains putrescible waste.

The waste acceptance procedures are tailored to mitigate the risk of any waste containing non-conforming materials. As the accepted waste in essence consists of minerals, concrete, bricks, tiles and ceramics, the presence of putrescible waste and/or fines materials can be reasonably assumed to be detectable by visual inspection. This greatly reduces the likelihood of contamination with significant amounts of non-conforming biodegradable materials from any waste code and particularly 19 12 12, that could lead to gas generation in volumes likely to cause lateral migration.

2.4 PATHWAYS

The potential pathway between source and receptors is lateral migration of landfill gas through the unsaturated subsurface. Factors influencing the potential of landfill gas to migrate through the subsurface include the local geology, the depth of waste below ground level, the landfill's lining system and the site-specific leachate levels as well as permanent groundwater levels at the Site.

The local geology surrounding the Site comprises topsoil over silty sands, and sand and gravel to between about 4 m and 6 m below ground level, underlain by clay[4]. The local geology constitutes a uniform matrix dominated permeable strata allowing for diffusive gas flow driven by concentration differentials only. Any gas emitted to the subsurface at the Site would tend to slowly disperse equally in all directions allowing for biological oxidation of methane to carbon dioxide during migration. In the absence of fissure or fracture flow dominated permeable strata (e.g. blocky sandstone or igneous rock), no highly permeable migration pathway is anticipated that would allow for more rapid advective gas migration driven by pressure differentials.

Groundwater levels surrounding the Site range between approximately 1 m and 4 m below the surface[4]. Lateral migration can only occur in the unsaturated zone above the groundwater level. As such, any potential lateral migration would therefore be predominantly shallow.

The basal geological barrier will be created by the in-situ Oxford Clay underlying the Site which provides a natural geological barrier. The sides of the quarry will be formed from in-situ sand and gravel which does not form a natural geological barrier. In keeping with the Landfill Directive, an artificial geological barrier will therefore be installed against the exposed gravel at the edges of the excavation. This will consist of a minimum thickness of 1 m of clay with a permeability of 1×10^{-7} m/s (or equivalent if lower permeability material is used).

The artificially established geological barrier will be produced from selected Oxford Clay sourced directly from the base of the Site and will act to intercept any residual gas potentially generated from the infill material from migrating laterally. With a geological barrier in place, any gas generated at the site from the DfR materials would not be able to migrate laterally so would instead vent through the uncapped surface of the infill following the path of least resistance. Either site-won topsoil or

[4] Pode Hole Quarry: Deposit for Recovery Permit Application – Hydrogeological Risk Assessment (2025).

selected imported waste soils will be placed on top of the inert waste as most of the Site will be restored back to farmland. The restoration soils will provide a medium for biological methane oxidation for any residual gas present within the Site.

2.5 RECEPTORS

The land use surrounding the Site is predominantly agricultural fields with associated farmhouses. The historical use of the Site was also agricultural. Bar Pastures Quarry, an extension to Pode Hole Quarry that is also operated by Aggregate Industries, is located immediately west/southwest of the Site. There is another mineral working located immediately west/northwest of the Site (operated by Land Logical Thorney Limited). There are two sensitive, residential receptors in close vicinity to the Site boundary. Both are located to the west of the Site along Willow Hall Lane and less than 20 m from the proposed infill (Figure 2-1).

2.6 RISK SCREENING

The waste acceptance procedures are tailored to mitigate the risk of any waste containing non-conforming materials. As the accepted waste in essence consists of minerals, concrete, bricks, tiles and ceramics, the presence of putrescible waste and/or fines materials can be reasonably assumed to be detectable by visual inspection. This greatly reduces the likelihood of contamination with significant amounts of non-conforming biodegradable materials from any waste code and particularly 19 12 12, that could lead to gas generation in volumes likely to cause lateral migration issues.

Should any biodegradable material still enter the Site and produce residual gas, the low permeable geological barrier will prevent its release laterally towards the receptors. Instead, any residual gas in the DfR infill would vent through the uncapped surface following the path of least resistance with methane emissions being abated by biological methane oxidation within the restoration soils. In addition, the local geology surrounding the Site would prevent any rapid, advective gas migration instead slowly dispersing equally in all directions allowing for biological oxidation of methane to carbon dioxide during migration.

Given the measures taken to prevent the initial filling of non-inert materials that could lead to gas generation, the nature of the local geology and the presence of a low-permeable clay liner geological barrier system, the risk of lateral migration at the sensitive receptors is deemed **very low**.

Regular in-waste gas monitoring will be undertaken to ensure the absence of any substantial gas generation (Section 3). Should monitoring indicate the onset of gas generation at any time, further measures will be taken to ensure the safety of the sensitive receptors (Section 4).

3 GAS MONITORING PLAN

Gas generation and the need for gas management are not anticipated at the Site due to the inert nature of the infilled waste materials. However, to validate that any gas source is negligible and is not migrating laterally internal and external monitoring will be undertaken at the Site. These data will also be valuable in supporting the eventual surrender of the Environmental Permit (Section 5).

3.1 GAS MONITORING BEFORE RESTORATION

Eight external combined gas monitoring boreholes will be monitored (six of which have been installed to date) with two of them located at the border to the sensitive residential receptors (**Drawing ESID10 – Monitoring and Extraction Point Plan**). Gathering monitoring data prior to and during the site preparation phase will allow the natural gas background conditions to be established and provide a reference for any changes once DfR infilling commences.

Monitoring will be undertaken on a monthly basis prior to the restoration works, quarterly during the works, and six-monthly in the post restoration phase (in line with the groundwater monitoring). This frequency of monitoring will be sufficient to enable the characterisation of seasonal variation and other environmental influences. Data collected will include methane, carbon dioxide, oxygen, atmospheric pressure and flow. In addition, weather conditions will be recorded for each monitoring event including temperature, rainfall and ground conditions, for example if the ground is waterlogged, frozen or covered in snow.

3.2 GAS MONITORING DURING RESTORATION

To monitor gas conditions with the waste mass, two boreholes per cell will be installed. The proposed Pode Hole restoration will comprise 10 filling phases (sections) and therefore 20 in-waste monitoring boreholes will be installed within 6 months of completion of waste placement in each phase. The in-waste monitoring boreholes in Phase IV(A) will be located as close as possible to the two sensitive receptors to monitor for any gas generation in their vicinity (**Drawing ESID10 – Monitoring and Extraction Point Plan**). All boreholes will be designed, installed and monitored in accordance with the borehole requirements described in LFTGN03.

In-waste monitoring boreholes will be monitored monthly for the first year following installation to demonstrate permit compliance. Data for methane, carbon dioxide and oxygen concentration (%v/v) as well as atmospheric pressure and flow will be collected. In addition, weather conditions will be recorded for each monitoring event including temperature, rainfall and ground conditions, for example if the ground is waterlogged, frozen or covered in snow.

After a review of the annual monitoring data and if it is deemed justifiable, the in-waste gas monitoring will revert to a quarterly. Should monitoring indicate the presence of gas generation within the waste mass, the gas action plan (Section 4) will be evoked.

External monitoring boreholes will be monitored for the same parameter as the in-waste monitoring boreholes.

4 GAS ACTION PLAN

The presence of gas generation will be considered a potential risk if gas concentrations in any in-waste borehole exceed gas concentrations for typical made ground[5]:

- 1.5 %v/v methane; and
- 5 %v/v carbon dioxide.

If these concentrations are exceeded during in-waste monitoring in any cell, the following actions will be taken within 4 weeks:

1. The monitoring will be repeated to identify if any aspect of the monitoring procedures or environmental factors (atmospheric pressure, weather conditions or rainfall) is likely to have influenced the results.
2. If the monitoring results are confirmed, the flow data will be used to calculate the Qhg of methane and carbon dioxide for each borehole and the worst case Qhg for the cell as defined by BS8485:2015.
3. If the individual borehole Qhg and worst case Qhg of the cell is <0.7, the hazard potential of the site is low[6] and no further action is required.
4. If the individual borehole Qhg or worst case Qhg of the cell is ≥ 0.7, additional investigations and actions are taken, including:
    a. A methane emissions survey of the affected cell. This will allow the operator to confirm whether surface emissions are present and if so, to quantify the extend of the affected area and magnitude of emissions.
    b. Review of the WAPs and waste records for the period in which the waste in the affected area was deposited. This will allow the operator to identify the potential waste stream giving rise to the gas generation and avoiding it in the future as well as making amendments to the WAP if required.
    c. Review of the existing external borehole data. This will allow the operator to quickly identify any increases from established background condition that may indicate breaches of the lining system and lateral gas migration, especially at the sensitive, residential receptors.
    d. If upon review an increasing trend in perimeter monitoring boreholes is identified, a full gas risk assessment will be conducted and appropriate safety measures for the sensitive receptors determined in consultation with the EA.

[5] CIRIA: Assessing risks posed by hazardous ground gases to buildings (C665)
[6] BS8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases to new buildings.

5 GAS COMPLETION CRITERIA

Following completion of restoration activities, the Site must meet one of two completion criteria to demonstrate to the EA that there is no remaining risk from gas[7].

5.1 COMPLETION CRITERIA 1

The EA is to be provided with a minimum of 12 datasets from regular monitoring (taken either monthly for a year or over a longer period) that show:

- Methane concentrations within the waste is less than or equal to 1.5 %v/v; and
- Carbon dioxide concentrations within the waste mass is less than or equal to 5 %v/v.

These limits must not be exceeded at any point during the monitoring period and apply throughout the waste.

The EA will accept that the gas completion criteria have been met if it can be shown that the concentration of methane and carbon dioxide within the waste is no greater than background concentrations (either natural sources or because of non-landfill activities) in the surrounding environment. This is also why it is important to have established the background concentrations through data collection prior to the site DfR activities commence (Section 3).

5.2 COMPLETION CRITERIA 2

Where the completion criteria of Option 1 cannot be satisfied, a minimum of 24 datasets from regular monitoring (taken either monthly for two years or over a longer period) are to be provided to the EA.

Where the methane concentrations are greater than 1.5 %v/v, the gas flow rate in the in-waste boreholes should be assessed. The flow rate from all in-waste boreholes should be monitored for at least 2 years and 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 0.7 l/hr.
- Recorded in any individual in-waste borehole is less than 70 l/hr.

The maximum flow rate of 70 l/hr must not be exceeded at any borehole during the monitoring period. This gas completion criteria reflect the characteristic gas situation 2 in BS 8485:2015 which describes a site with a low hazard potential.

[7] EA Guidance: Landfill and deposit for recovery: aftercare and permit surrender (Landfill and deposit for recovery: aftercare and permit surrender - GOV.UK, accessed 15/05/2025).

6 CONCLUSION

A Gas Risk Assessment has been prepared in support of its application for an Environmental Permit for waste Deposit for Recovery at Pode Hole Quarry.

A Conceptual Site Model in relation to lateral gas migration from potential gas generation in the infill was developed following the source-pathway-receptor principle. The assessment found that:

- The Waste Acceptance Procedures are tailored to mitigate the risk of any waste containing non-conforming materials. As the accepted waste in essence consists of minerals, concrete, bricks, tiles and ceramics, the presence of putrescible waste and/or fines materials can be reasonably assumed to be detectable by visual inspection. This greatly reduces the likelihood of contamination with significant amounts of non-conforming biodegradable materials from any waste code and particularly 19 12 12, that could lead to gas generation in volumes likely to cause lateral migration.
- The artificially established geological barrier may be produced from selected inert material of from Oxford Clay sourced directly from the base of the Site and will act to intercept any residual gas potentially generated from the infill material from migrating laterally. With a geological barrier in place, any gas generated at the site from the DfR materials would not be able to migrate laterally so would instead vent through the uncapped surface of the infill following the path of least resistance. Either site-won topsoil or selected imported waste soils will be placed on top of the inert waste as most of the Site will be restored back to farmland. The restoration soils will provide a medium for biological methane oxidation for any residual gas present within the Site.
- Given the measures taken to prevent the initial filling of non-inert materials that could lead to gas generation, the nature of the local geology and the presence of a low-permeable clay liner geological barrier system, the risk of lateral migration at the sensitive receptors is deemed **very low**.

The Gas Monitoring Plan sets out the requirements for regular in-waste gas monitoring to ensure the absence of any substantial gas generation as well as requirements for external boreholes to establish local background concentrations for methane and carbon dioxide.

The Gas Action Plan sets out the measures taken to ensure the safety of the sensitive receptors should in-waste gas monitoring indicate the onset of gas generation at any time. This will include additional monitoring and consideration of gas flow, a review of the WAPs, methane surface emissions monitoring and review of the existing external borehole data. The latter will allow for quick identification of any increases from established background condition that may indicate breaches of the lining system and lateral gas migration, especially at the sensitive, residential receptors. If such trends are observed, a full gas risk assessment will be conducted and appropriate safety measures for the sensitive receptors determined in consultation with the EA.

The GRA concludes with the Gas Completion Criteria that the Site must meet following completion of restoration activities to demonstrate to the EA that there is no remaining risk from gas.

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