MOTT MACDONALD

Ferry Road Landfill

Qualitative Gas Risk Assessment

October 2021

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Executive summary

The licensed landfill of Ferry Road is an area of filling that is contained and separated from former tipping through engineered layers. The aim of this document initially was to consider the gas risk from the licensed site. However, the licensed site is situated on approximately 4 million cubic metres of municipal, commercial and industrial wastes that were deposited over a prolonged period during the 1970s. In addition, the area surrounding the site has been the subject of significant historic disposal that pre-dates the 1970s. As a result, it is likely that the developments in the surrounding area have the potential to be impacted by gas from numerous sources.

Observation wells were installed at the time of the licensed disposal, but these are located in the former waste. It is unlikely that if monitoring wells were installed that these could be advanced totally in natural ground. As a result, there does not appear to be any benefit in installing further wells.

Instead, it is recommended that any development in the vicinity is required to conduct a gas assessment and include gas protection measures. This appears to have been the approach of the planning authority as the closest developments include gas protection measures.

Whilst no specific gas control measures are installed in the licensed site (other than the engineered containment), the surrounding area is subject to gas extraction for the purposes of power generation. Power generation is unlikely to be feasible over an extended period, as gas flow has reduced from a reported 2,500m^3/hr when the system was first installed down to approximately 80m^3/hr during recent measurements. A new gas contract has been commissioned with RPS. Once power generation is unproductive, it will be necessary to install a low methane, low flow gas flare. Extraction should continue for as long as feasible. Beyond this time, consideration should be given to undertaking active venting without flaring.

This risk assessment should be reviewed either within the next six years, as is typically required, or should the active extraction system with energy recovery cease, whichever is earlier.

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1 Introduction

This section identifies the objectives of this report. Normally, a gas risk assessment would be quantitative in nature, but little information exists on the wastes deposited and therefore this assessment is largely qualitative. A GasSim model has been generated and used to provide some quantitative information but this needs to be considered with care.

1.1 General

Mott MacDonald Limited was commissioned by the County Council of the City and County of Cardiff (Council) to prepare an aftercare management plan for the Ferry Road Landfill. As part of this appointment, it was identified that the site has not been subject to a gas risk assessment and, therefore, this document has been produced to consider the risks associated with landfill disposal resulting from the permitted landfill installation. This gas risk assessment is primarily qualitative in nature because there is insufficient information relating to the historic disposal of wastes at the site. However, where possible, consideration has been given to recorded values to support the qualitative findings. In addition, a GasSim model has been prepared, but lacks known inputs, therefore the results need to be considered on that basis.

This gas risk assessment draws upon information gathered from monitoring records collected by the original gas extraction contractor (Infinis), and from the Council.

1.2 Objectives of this report

This report presents the conceptual site model for the landfill area and characterises the source term and the potential pathways and receptors. The objectives of this report are to:

- Consider the production of landfill gas from the Ferry Road Landfill;
- Identify potential hazards posed by landfill gas generation;
- Identify potential receptors and pathways for gas migration;
- Provide a qualitative health risk assessment as a result of landfilling activities to those potentially exposed; and
- Propose and assess realistic mitigation measures to remove or minimise identified potential pollution or Health and Safety risks.

1.3 Report structure

This report loosely follows the requirements of “Environmental Permitting application for a landfill permit - Landfill Gas Risk Assessment” template, Environment Agency 2010. As such it includes the following sections:

- Project context;
- Conceptual site model;
- Landfill gas risk assessment; and
- Conclusions.

Certain sub-sections related to quantitative assessment have not been considered. Gas management is covered throughout the document. Where the site is already subject to gas management measures, these are described together with a recommendation about future modifications.

2 Project context

The following section provides the background, environmental setting and context for the site, the disposal operations, the closure and known historic deposition within the vicinity of the site.

2.1 Landfill location

The Ferry Road Landfill site comprises an area of approximately 18ha (45 acres) owned by Cardiff City Council, located within the Grangetown area of Cardiff, centred at NGR 317420, 173790. The site is a circular shaped hill that lies between Ferry Road Retail Park to the east and the River Ely to the west. The site is currently used as public open space (Grangemoor Park), with public footpaths circling the site. The site location is presented in Figure 2.1.

Figure 2.1: Site boundary

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The site is vegetated and grassed, with areas of dense vegetation particularly in the northern and eastern boundaries. The observed principal site surroundings are summarised in Table 2.1.

Table 2.1. Site surroundings.

Area	Site Use
North	Disused Grangetown Gasworks is located immediately to the north, with IKEA and residential properties to the northeast and Leckwith Industrial Estate to the northwest.
East	Ferry Road Retail Park is located immediately to the east of the site, with Ferry Road and residential properties further east.

Area	Site Use
South	Dunleavy Drive is located along the southern perimeter of the site, with Dunleavy Drive Retail Park to the southeast. The A4232 Grangetown Link road runs in an east-west orientation, with residential and commercial properties further south.
West	River Ely forms the western boundary of the site. Leckwith Industrial Estate and Westpoint Industrial Estate are located further west.

2.2 Site history

2.2.1 Pre-licensed site history

A full site history, making reference to historic mapping is included within "Ferry Road Landfill - Contaminated Land Desk Study", Mott MacDonald Limited, September 2021.

Figure 2.2 shows the extent of waste disposal tipping operations within the vicinity of the landfill that pre-dated the disposal operations at the site. It shows that much of the area within this location was tipped with approximately 6m depth of municipal and industrial wastes.

Figure 2.2: Plan showing historical tipping, pre-dating disposal at Ferry Road Landfill

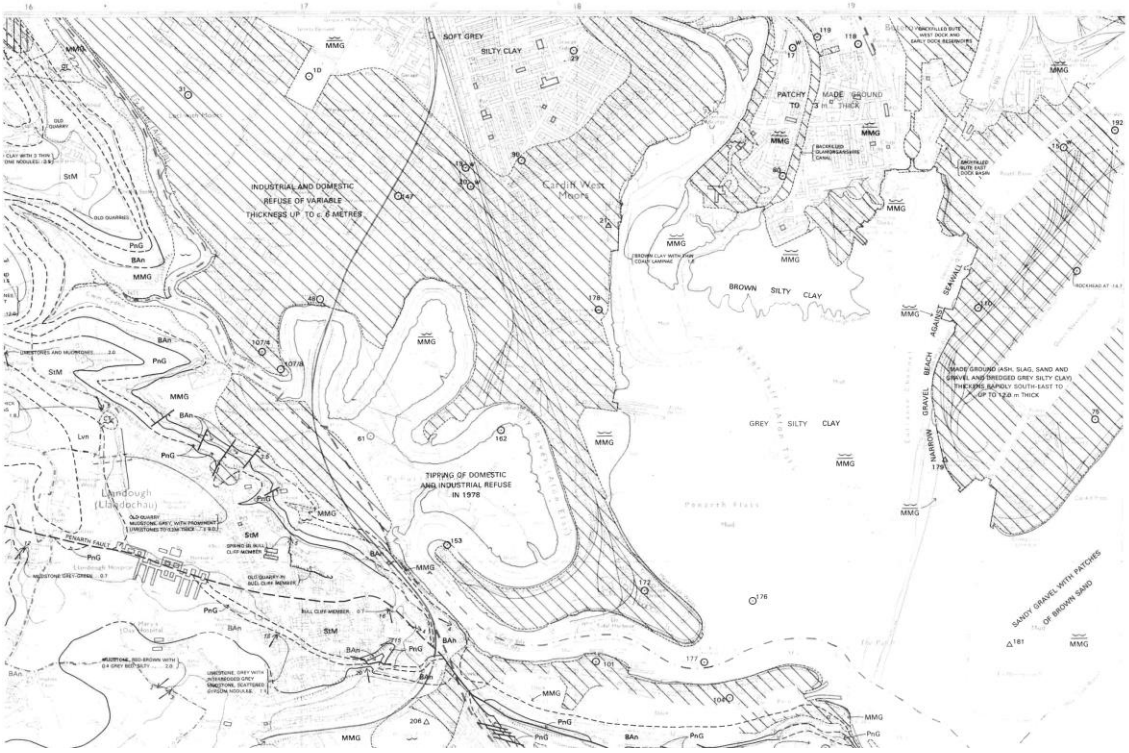


Figure 2.2 appears to show that the area surrounding the site had apparently already been the subject of significant historical tipping before largescale tipping was to be undertaken in the 1970s up to the end of the 1990s. Historical mapping includes references to several clay pits associated with brick manufacture in maps dating from *circa* 1900 in areas that were developed by the 1940s. In 1915-1920 refuse heaps were shown to occur 45m north west of the site, with a further area of filled marshland 100m north west that was likely to comprise domestic rubbish, cinders, animal bones, pottery as part of a gasworks site. Between 1972 and 1976 there was a refuse site to the north of the licensed site.

It was reported that the wider site first began accepting waste in 1971. Prior to the start of tipping 1971 the site comprised the meandering River Ely (as shown in Figure 2.2) and

associated flood plains. In 1969 an Act of Parliament was passed to enable construction of a new cut across the meanders of the River Ely. The cut forms the present-day line of the river. Cardiff City Council used the old riverbed to dispose of builders' rubble, commercial waste and municipal refuse. This original landfill is unlined and achieves a height of around 20m above the surrounding area.

Between 1982 and 1986 there was extensive tipping around the area. There were six refuse tips labelled in and around the site comprising two on the northern limit, one on the eastern limit, two on the southern limit and a final site to the south. Two of these are described as public sites and there was a weighbridge at the site. Former refuse disposal was also identified at two locations 80m southeast of the licensed site and another 150m to the south of the licensed site.

The meander was filled together with much of the adjacent land, with tipping continuing up above the surrounding ground level. Historical aerial photographs indicate the refuse site was developed, at least in part, in individual cells. Wastes accepted on site comprised municipal waste, including household, commercial, industrial, civic amenity wastes, street sweepings and litter, and later contaminated general wastes, contaminated soil and subsoil, and bonded asbestos associated with the redevelopment of the Cardiff Bay area. It is understood that approximately 4 million cubic metres of waste were buried onsite.

2.2.2 Licensed site history

Landfilling with commercial and household waste continued at the site until 1994. In 1994 the tip was closed and the land entered into Cardiff Bay Development Corporation (CBDC) ownership. The CBDC created a new retail park on the old industrial site to the east.

Overall, there has been significant disposal of material both in the distant past and the more recent past in and around the licensed site, where much of the material placed is likely to have the potential to generate gas.

The CBDC undertook the following preparatory work for the development for Cardiff Bay Retail Park and Ely Fields Site (respectively):

- Material with unacceptably high levels of contamination, together with refuse deposits associated with the municipal landfill along the site's boundary, were removed; and
- The refuse deposits associated with the municipal tip down to the level of the underlying estuarine mud flats, were removed and replaced with imported fill.

The excavated material was deposited on an area of the landfill. The site was, therefore, reactivated under a new Waste Management Licence. The area comprised a mounded area to the north of the A4232.

The Ferry Road landfill was, therefore, re-opened under licence, and received wastes scraped from the surrounding areas.

The "Ferry Road Landfill, Closed Landfill Review", April 2018 prepared by Ramboll Environment and Health UK, lists the following information under their permitted waste types and quantities review of the site's 1994 waste management licence.

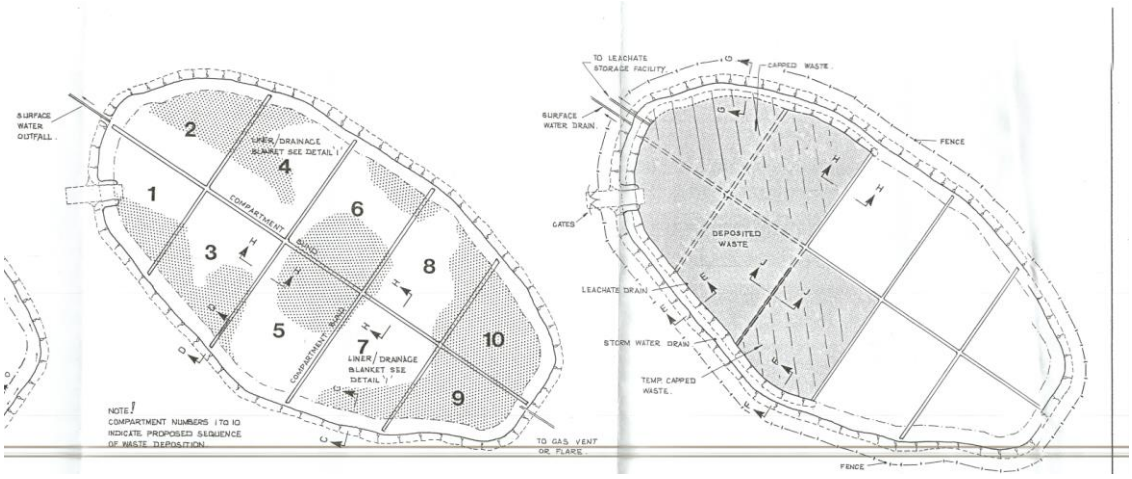
- In Phase I (Disposal Zone 2, as referred to in Ove Arup and Partners Report 95/2592): Industrial wastes constituting contaminated soils, hardcore and similar materials arising from the excavation of land identified as Cardiff Bay Retail Park in Figure 1 of the Working Plan, spoil arising from the construction of the surface water drain to serve the Retail Park Site - maximum quantity 60,000 tonnes; and
- In Phases II and III (Disposal Zone 1): Industrial wastes comprising excavated soils, hardcore and similar materials from municipal refuse arising from construction of the gas cut-

off wall and ancillary works, industrial wastes comprising contaminated soils and municipal refuse (including asbestos) arising from the excavation of land identified as Ely Fields, spoil arising from the construction of the surface water drain between the retail park site and spoil arising from the construction of the permanent access road serving Ely Fields - 325,000 tonnes.

2.2.3 Licensed site construction

The site was filled in ten phases as shown in the following figure:

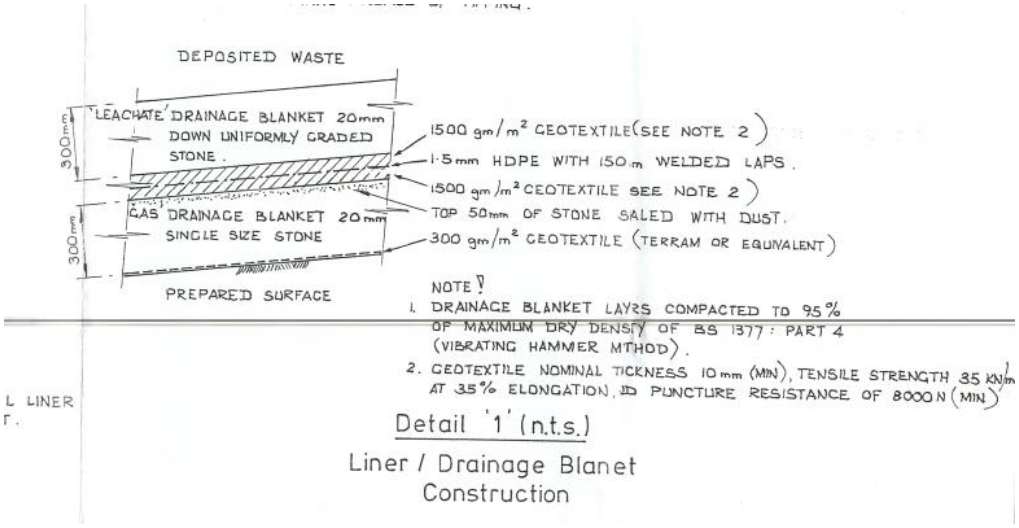
Figure 2.3: Extract of "Disposal cell construction plan – WSK 48 Rev A" showing phasing scheme



Source: Ove Arup & Partners

The site was engineered to provide containment above the historical tipping. This is shown in

Figure 2.4: Extract of "Disposal cell construction plan – WSK 48 Rev A" showing proposed containment detail



Based on the tonnages identified, the total maximum quantity of waste is of 385,000 tonnes.

The landfill was covered, restored and developed to create Grangemoor Park, which was completed in 2000.

2.3 Geology

2.3.1 Made Ground

British Geological Survey (BGS) GeoIndex[1](1:50,000) does not record the presence of Made Ground on site, however immediately surrounding the site are artificial deposits of undivided Made Ground. BGS Lexicon[2] describes this as *"Made Ground is an area where the pre-existing (natural or artificial) land surface is raised by artificial deposits. The purpose of Made Ground is unspecified. Variable composition".*

2.3.2 Superficial Geology

BGS GeoIndex[1](1:50,000) indicates that the superficial geology below the site is Marine or Estuarine Alluvium comprising clay, silt and sand. BGS Lexicon[2] describes this as *"Tidal flat deposits, including mud flat and sand flat deposits, are deposited on extensive nearly horizontal marshy land in the intertidal zone that is alternately covered and uncovered by the rise and fall of the tide. They consist of unconsolidated sediment, mainly mud and/or sand. Normally a consolidated soft silty clay, with layers of sand, gravel and peat. Characteristically low relief."*

2.3.3 Bedrock Geology

According to BGS GeoIndex[1](1:50,000) the bedrock geology of the site and surrounding area is the Mercia Mudstone Group. BGS Lexicon[2] describes this as *"Dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas. Thin beds of gypsum/anhydrite widespread; sandstones are also present".*

2.3.4 Geological Structure

According to BGS GeoIndex[1] and BGS paper maps (1:50,000)[3], there are a series of five normal 'step' faults trending northeast-southwest located approximately 600m southwest of the site. Another normal fault trending northwest southeast is located approximately 800m southwest of the site.

BGS paper maps[3] shows that bedrock is dipping 5° to the south.

2.4 Hydrogeology

Aquifer designations for the site have been identified using the Groundsure GeoInsight Report[4] and BGS GeoIndex interactive maps[1].

The bedrock (Mercia Mudstone Formation) is designated as a Secondary B aquifer defined as *'predominantly lower permeability layers which may store and yield limited amounts of groundwater'* and *'localised features such as fissures, thin permeable horizons and weathering are generally the water-bearing parts'.* It is also noted that this is a medium vulnerability bedrock aquifer.

The Marine or Estuarine Alluvium superficial deposits are designated as a Secondary (undifferentiated) aquifer, assigned where it is not possible to attribute either category A or B to the rock type. Secondary A aquifers are *'permeable layers capable of supporting water supplies at a local rather than strategic scale'*, while Secondary B aquifers are *'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised*

[1] BGS GeoIndex. Available at: GeoIndex - British Geological Survey (bgs.ac.uk). (Accessed 23rd July 2021)
[2] BGS Lexicon [online]. Available from: BGS Lexicon of Named Rock Units - Result Details (Accessed on 15th July 2021)
[3] BGS 1986. Cardiff England and Wales Sheet 263 Solid Geology, 1:50000 Series. (Accessed 23rd July 2021).
[4] Groundsure GeoInsight Report, No. 8068388. Accessed 23rd July 2021.

features such as fissures, thin permeable horizons and weathering'. It is also noted that this is a medium vulnerability superficial aquifer.

It is known that Glaciofluvial Gravels are present beneath the site with a groundwater table at 4.5m Above Ordnance Datum (AOD)[5], however this is not highlighted in the published information.

The site is not located within a Groundwater Source Protection Zone[1]. There are no recorded groundwater abstraction points at or within 250m of the site. The nearest groundwater abstraction point is located 730m NE of the site, where up to 108m^3 of water is abstracted daily for use as a groundwater source heat pump (Licence Number: WA/057/0025/013, NGR: 318104, 174494)[1].

In terms of site surrounds, the hydrogeological conditions beneath the former Grangetown Gasworks include two aquifers[6]. The first is within Made Ground and low permeability Alluvium, the second is in Glaciofluvial Gravels confined by overlying Alluvial Clays. This differs to the onsite site conditions insofar as within the original River Ely channels, the river has cut through the Alluvium to connect directly with the gravels[5]. Therefore, the surrounding hydrogeological model differs slightly from the on-site model due to the lack of full impermeable cover from the Alluvium on site. Groundwater was not encountered in the bedrock geology of Mercia Mudstone within the site surrounds[6].

2.5 Hydrology

Using Ordnance Survey (OS) Mapping, to the immediate west and southwest of the site is the River Ely. There is a small unnamed tributary to the River Ely originating to the north of the site and running parallel to the railway line. At the eastern boundary of the site, there is a pond located adjacent to the Ferry Road Retail Park. On site, there are three circular ditches that follow the approximate perimeter shape of the landfill. One of these ditches is located at the base of the landfill following the 10m contour, another follows the 20m contour, and the third follows the 25m contour. No discharge features for these ditches were visible during the Site Walkover.

According to Natural Resources Wales (NRW) [7] the site is not at risk from flooding by the sea but the surrounding coastal area and the urban area of Grangetown is at low risk of flooding from the sea. There is medium risk of river flooding along the River Ely's banks. There are several pockets of low to high-risk areas of flooding from surface water and small watercourses, located around the NE site boundary and the public footpath at the top of the site.

According to the Worley Parsons Factual Report[3], the Water Framework Directive River Basin Management Plans NRW classified the water quality of the River Ely as poor in 2015.

2.6 Ground Profile

The landfill itself has a 'domed' topography with the highest elevation at approximately 31m AOD, in the northern central portion of the site. The ground slopes downwards to the north, east, south and west generally to around approximately 18m A0D. The lowest point lies at 9m AOD in the south east. Grangemoor Park occupies the site itself, which comprises undeveloped grassed areas crossed by tracks / paths and a concentric network of drains broadly following the contours of the dome. Peripheral woodland is present and a pond is located on the eastern boundary at the lowest point of the site.

5 Geotechnology. 2021. Ferry Road Landfill Cardiff Site Inspection Report.

6 Worley Parsons. 2015. Factual Site Investigation Report, Ferry Road, Grangetown.

7 Natural Resources Wales Flood Risk Map Viewer [online]. Available from: Geocortex Viewer for HTML5 (cyfoethnaturiolcymru.gov.uk) (Accessed 15th July 2021)

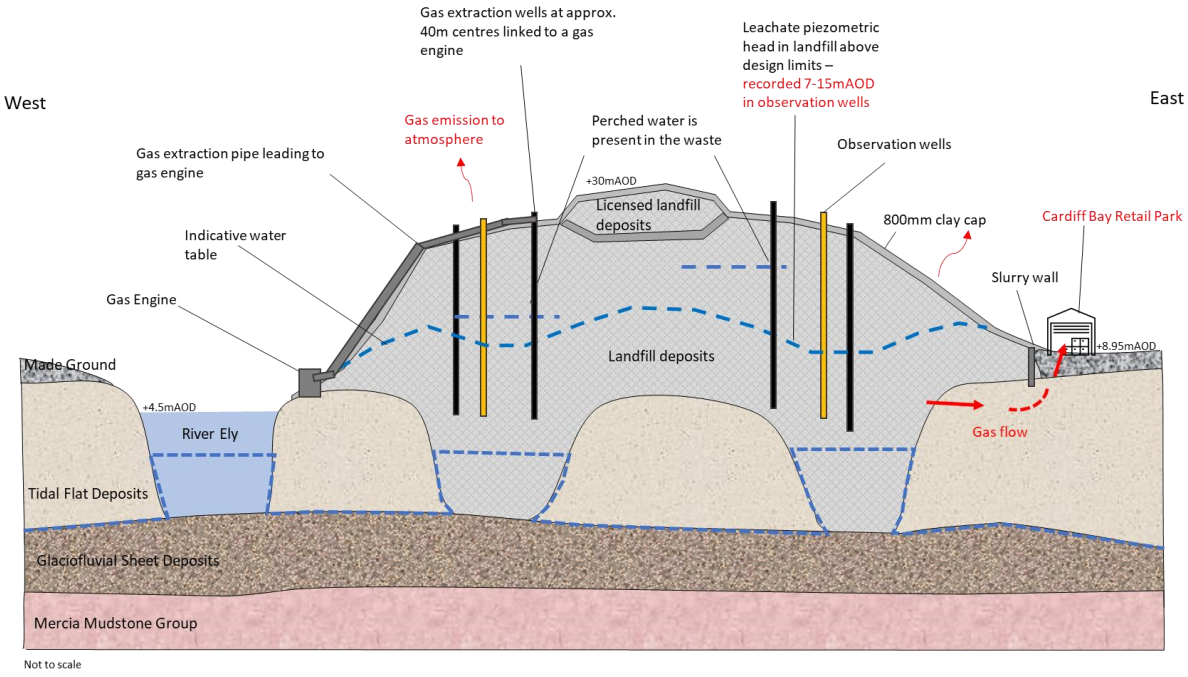
3 Conceptual site model

A conceptual site model has been prepared to consider the source, any pathways and sensitive receptors close to the site.

3.1 Introduction

The following paragraphs highlight the gas source; the pathways by which potential contaminants can enter the environment from a source, migrate to and affect the surrounding area; and potentially sensitive receptors around the landfill site.

Figure 3.1: Conceptual Site Model - Gas



Source: Mott MacDonald Ltd

3.2 Source

As discussed in Section 2.2.2, the licensed landfill at Ferry Road is believed to have received 385,000 tonnes of non-hazardous domestic, commercial and industrial wastes.

There are a number of hazards associated with landfill gas namely flammability, explosivity, toxicity and asphyxiation. There are also environmental nuisances that are associated with the escape of landfill gas into the atmosphere and soils; not least odour generation and vegetation die back.

An active gas management system has been installed in the land surrounding the licensed landfill comprising a network of vertical gas extraction wells, connected to a system of gas mains and spurs. The wells are spaced at approximately 45-50 metre centres. The main pipe is eventually connected to a landfill gas power generation plant that has, until recently, been operated by Infinis. This contract has now come to an end and the site is now operated on behalf of the Council by RPS. The gas extraction system will generate a negative pressure in the site, which will mean that there is a reduced potential for gas migration. There are no gas controls in the landfill that was licensed prior to filling.

Monitoring has been undertaken at the gas extraction wells and the manifolds since August 2010. For the first four months monitoring was undertaken for methane, carbon dioxide, oxygen, hydrogen sulphide and atmospheric pressure at fortnightly intervals. These parameters were then monitored typically at monthly intervals until July 2017, and then every second month until August 2020, which is when Infinis were no longer contracted to manage the gas extraction system.

An extract of a plan showing the locations of the 28 gas wells and 4 manifolds is provided as Appendix A. It shows that extraction wells are collected as follows:

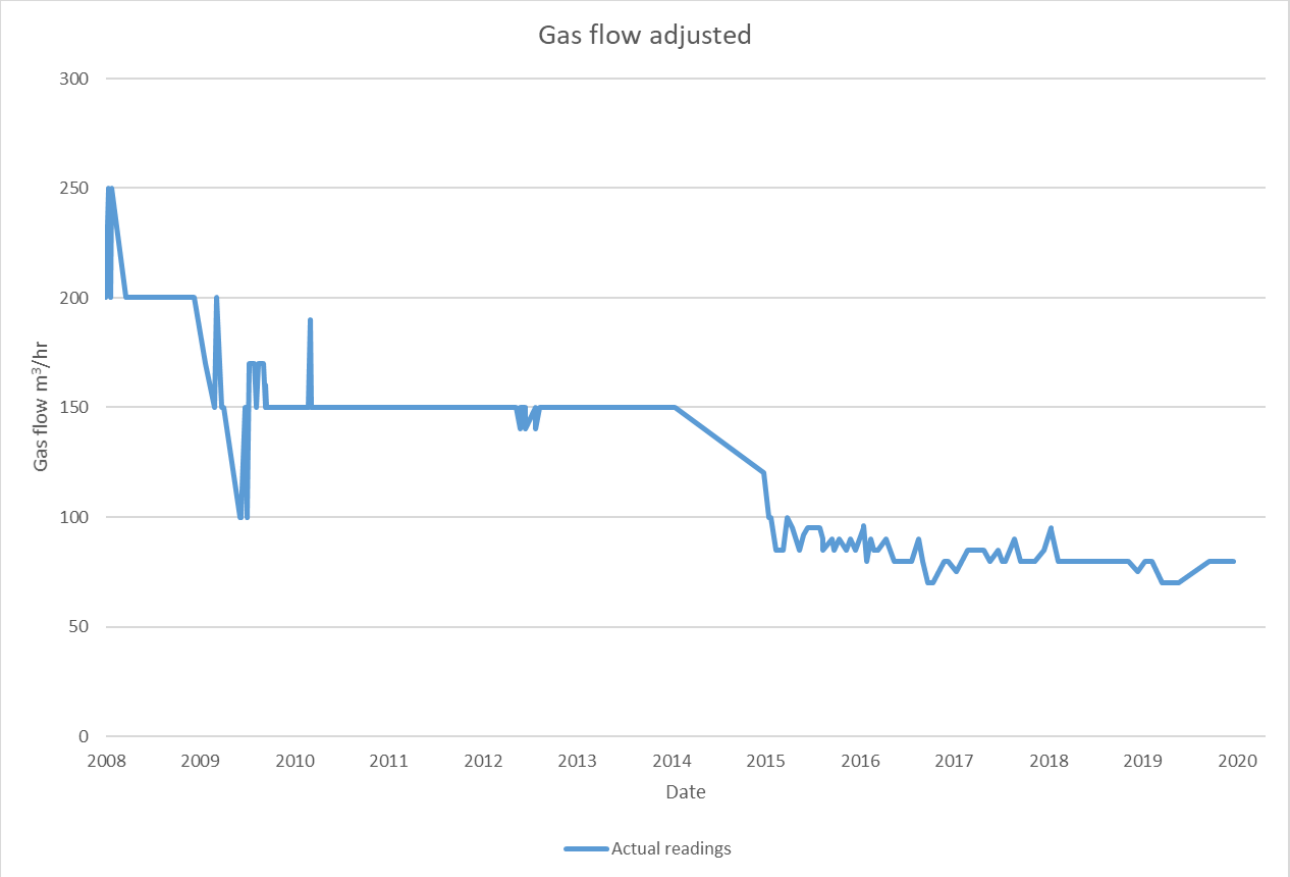
- Manifold 1 Wells 23-28;
- Manifold 2 Wells 1-4;
- Manifold 3 Wells 5-13; and
- Manifold 4 Wells 14-22.

The extract also shows the location of the gas engine.

Typically, each manifold has a gas concentration of approximately 40% methane and 20% carbon dioxide, with trace oxygen. The monitoring results at the manifolds are presented graphically in Appendix B.

The gas flow received at the engine is shown in Figure 3.2. These results have been adjusted to remove the occasions where either no monitoring was undertaken, or very low flow recorded. Instances where very low flow were recorded would be individual occurrences or issues that have occurred and resolved. By removing these monitoring results, it is clearer to see the general trend in gas flow.

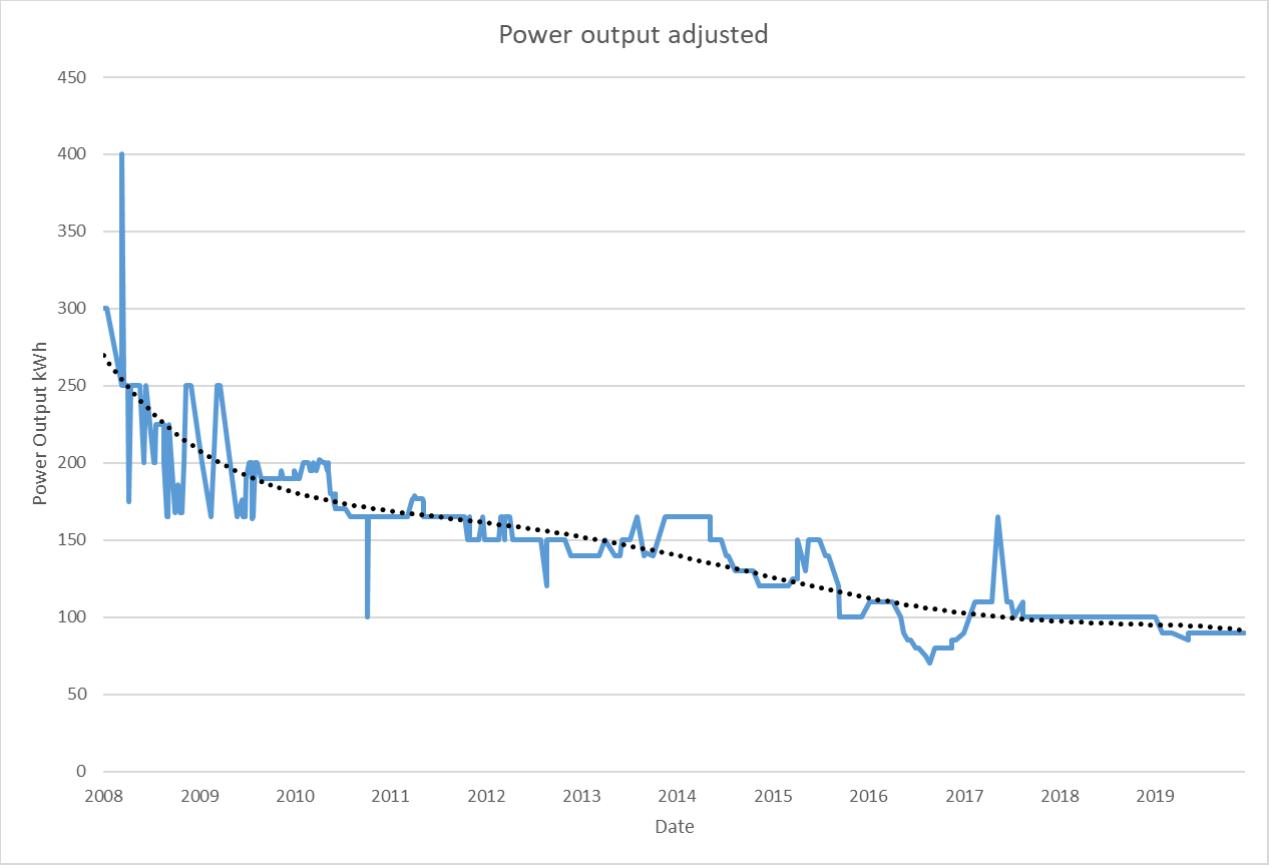
Figure 3.2: Gas flow recorded over time



Source: Infinis

The power output observed is included as Figure 3.3. As with Figure 3.2, the results where no power output was reported have been removed to get a better indication of the trend. A trendline has been included, which shows the power output falling slowly over time.

Figure 3.3: Power output

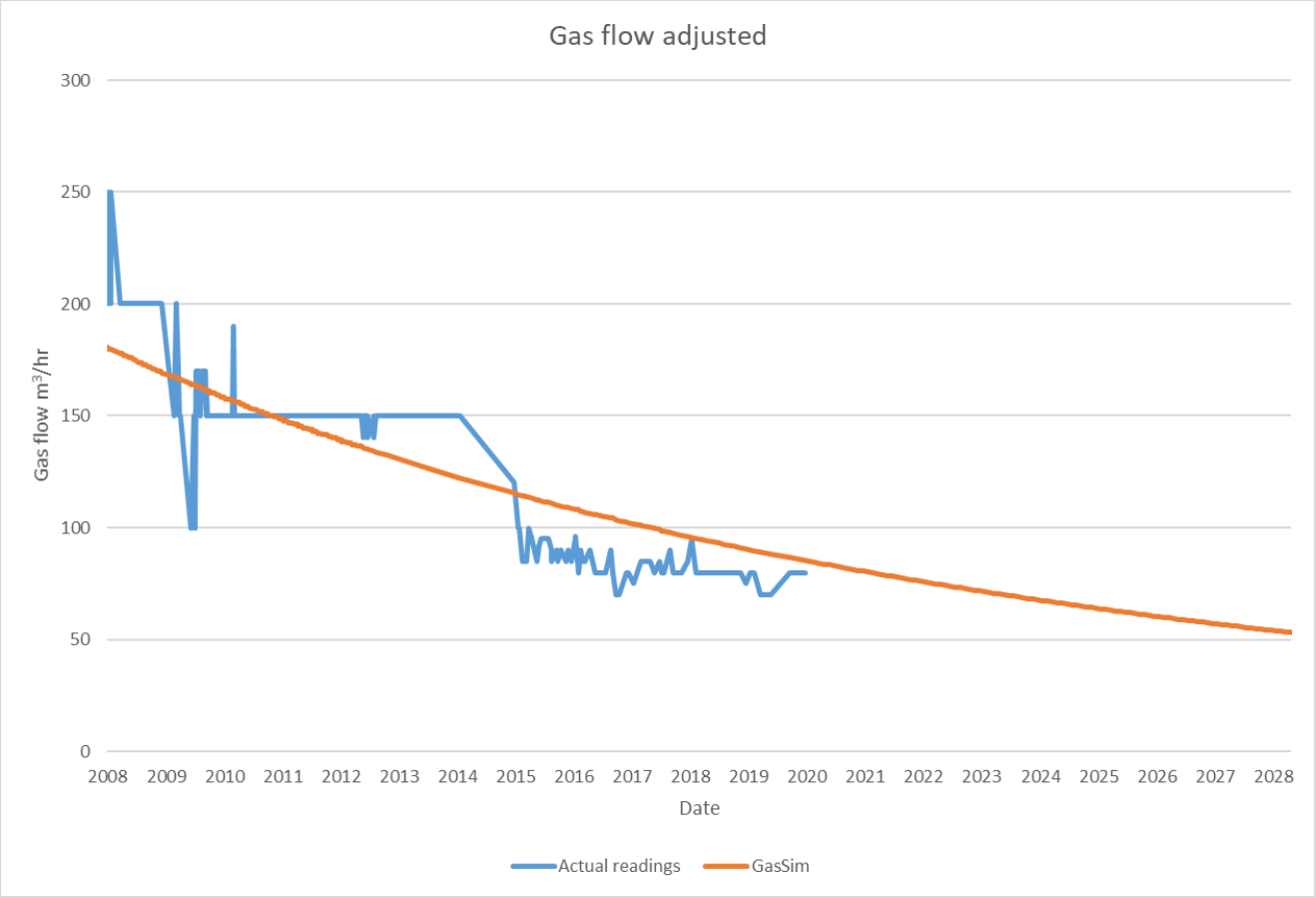


Source: Infinis

What this shows is that there is a dwindling gas supply and that the potential for power generation is reducing. There may come a time within the next few years when continuous energy generation may not be feasible. At this stage it may be necessary to revert to a low flow, low methane flare.

We have tried to estimate the gas flows over subsequent years. We have done this by attempting to replicate the gas flows in a GasSim model. The output to this is included in Figure 3.4.

Figure 3.4: Estimated future gas flow



Source: Infinis (actuals) Mott MacDonald (GasSim based estimate)

It is unclear how long the engine will be effective for, but it would appear that the profile may be insufficient for continuous operation by 2028

There is no perimeter monitoring at this site. This is largely because there does not appear to be any part of the adjoining land that is not subject to the impacts from infilling.

No vegetation die back has been noted outside the boundary of the site.

3.3 Pathways

There are a number of pathways whereby landfill gas has the potential to affect on-site and off-site receptors. These include:

- Fugitive emissions of landfill gas from the surface of the landfill into the atmosphere where they will be diluted and dispersed;
- Lateral migration of landfill gas through the landfill liner and subsurface; and
- Emissions of landfill gas combustion products from landfill gas utilisation plants such as gas engines and flares. Emissions will be from stacks associated with engines and flares and as with fugitive releases will be diluted and dispersed in the atmosphere depending on meteorological conditions.

Human exposure to landfill gas emissions in the atmosphere may arise via a number of pathways as follows:

- Direct inhalation of airborne contaminants and particles, including airborne contaminants that may arise from lateral migration of landfill gas;
- Dermal contact with contaminated soils and dust; and
- Contamination of vegetation via deposition and uptake through leaves and roots.

Human exposure to contaminants present in landfill gas can also occur from the ingestion of other food products such as locally grown dairy products and meat (exposure occurs by the animal ingesting contaminated soils and vegetation). As this site is now a park, the potential for ingestion of food products ingested is unlikely to occur and has not been considered further.

3.4 Receptors

The following receptors have been considered in this assessment and are summarised in the table below. The receptors listed are the closest buildings of a commercial/industrial nature in each direction from the site.

Reference	Building	Direction from site	Distance*
1	McDonalds restaurant	East	30 metres
2	Housing (Ferry Road)	North East	140 metres
3	Pure gym	North	40 metres
4	Starbucks	South	30 metres
5	Asda petrol station	South East	20 metres

* Distances indicated relate to distances to the whole waste deposits since the 1970s and not the licensed facility.

It should be noted that there is a slurry wall between the former deposits in the 1970s and the retail development to the east of the site.

In addition to the properties listed above, other sensitive receptors include visitors to the park.

4 Gas risk assessment

The assessment considers the risk associated with gas emerging from both the licensed site and the surrounding deposits that were disposed of during the 1970s.

4.1 The Nature of the Landfill Gas Risk Assessment

The licensed landfill site is contained, but is not subject to gas control. The gas extraction system manages the gas from the historic tipping undertaken prior to the deposition of waste in the licensed landfill. Gas escape from the licensed cells would be managed by this external system.

The Council was responsible for the disposal operations that pre-date the development of the licensed cells and retain the responsibility for managing gas from the earlier deposits.

It is difficult to establish if there are any off-site impacts, partially because there are no perimeter boreholes and, even if there were, they could be impacted by tipping that was undertaken prior to the placement of wastes in the 1970s.

The planning authority appears to have taken the stance that all developments in the vicinity could be impacted by gas. This view appears to have been accepted since the time when landfill gas was realised to be a risk to the surrounding environment. The commercial units to the east are separated from the landfill through the installation of a cut-off wall.

Despite this, gas protection measures were included within the design of the retail centre behind the cut-off wall. Gas vents (in the form of cowls) are visible and have been included as features within the structural design.

The most recent development planning application within the vicinity was for a site approximately 300metres to the north of the waste deposits placed in the 1970s. A gas assessment was undertaken that showed no methane, but elevated carbon dioxide (peaking at 8.7%). As a result, gas protection measures were provided in the form of a gas membrane, underfloor venting and duct entrances sealed. The remoteness of the development from the tipping under consideration is likely to demonstrate how the entire area is impacted by gas from historic tipping that pre-dates the tipping in the 1970s.

The whole site, including the waste deposited in the 1970s was capped with an 800mm low permeability clay layer overlain by a 350mm thick soil layer, in 1998. Gas extraction was installed and was originally understood to be generating 2,500m^3/hr of gas. This has subsequently reduced to approximately 100m^3/hr of gas as gas generation tails off over time. Gas extraction should reduce the potential for gas escape, whilst the wells are enclosed to ensure that they are inaccessible to the public. As a result, in relation to the public, the risk from gas generation should be negligible.

4.2 The Proposed Assessment Scenarios

4.2.1 Lifecycle Phases

The site has been definitively closed for an extended period. No further engineering is anticipated. A walkover was conducted and did not identify any works required.

4.2.2 Accidents and their Consequences

A qualitative assessment is typically undertaken considering the impact of accidents and resulting damage to the engineered systems. This has to take into account the age and status of the site, which is now a publicly accessible park.

Table 4.1: Matrix of Accidents and their consequences

Identified Accidents/Failure for Edgefield Landfill	Consequence(s)	Risks Evaluation			
		Likelihood	**Severity**	***Severity of Consequences**	****Magnitude of Risk**
• Failure of containment	• Landfill gas migration	Unlikely	Minor	3	Insignificant
• Loss of gas collection capability	• Build-up of potentially explosive or asphyxiative landfill gas in service ducts or other voids/ confined spaces • Potential impact to local amenity	Somewhat unlikely	Noticeable	8	Acceptable
• Failure or leachate extraction system which may effect landfill gas management	• Damage to property • Odour nuisance • Atmospheric pollution	Somewhat unlikely	Minor	4	Insignificant
• Gas extraction system failure		Somewhat unlikely	Minor	4	Insignificant
• Site instability	• Damage to leachate/ landfill gas management infrastructure	Unlikely	Noticeable	6	Insignificant

Note: See Table 2.5: Severity Likelihood Matrix, Guidance on the Management of Landfill Gas, EA, 2002, Table 2.6: Risk Evaluation, Guidance on the Management of Landfill Gas, EA, 2002

The accidents highlighted in Table 4.1 reflect the fact that the waste was deposited over forty years ago. As a result, the potential for extensive gas migration will have reduced from when the waste was first deposited.

The potential for gas migration can still occur and hence it will be necessary for gas extraction to continue for the foreseeable future and for the planning authority to require gas assessments to be undertaken for any nearby developments.

4.3 Numerical modelling

4.3.1 Justification for Modelling Approach and Software

As identified, the wastes that lead to the greatest risk reflect that placed in the 1970s, which amounts to approximately 4 million cubic metres of municipal, commercial and industrial wastes. No further information exists relating to this waste and therefore it is difficult to develop a suitable numerical model.

As a result, the aim has been to develop a model that generates an available gas flow that is validated by the gas extraction data.

A GasSim model has been prepared to support to determine the anticipated bulk gas generation for methane and carbon dioxide.

4.3.2 Model Parameterisation

For the waste inputs to this model it has been assumed that waste was deposited at a consistent rate between 1971 and 1995. The 4 million cubic metres of waste, therefore equates, for an assumed density of 1 tonne per cubic metre, to 160,000 tonnes per year.

Typically, a site that has been fully engineered would be expected to have a gas collection efficiency of approximately 70%-80%. To provide a more conservative approach, the collection efficiency has been considered to be 60%.

4.3.3 Sensitivity Analysis

As the model has been developed on the basis of validated gas flows, no sensitivity analysis has been undertaken.

4.3.4 Model Validation

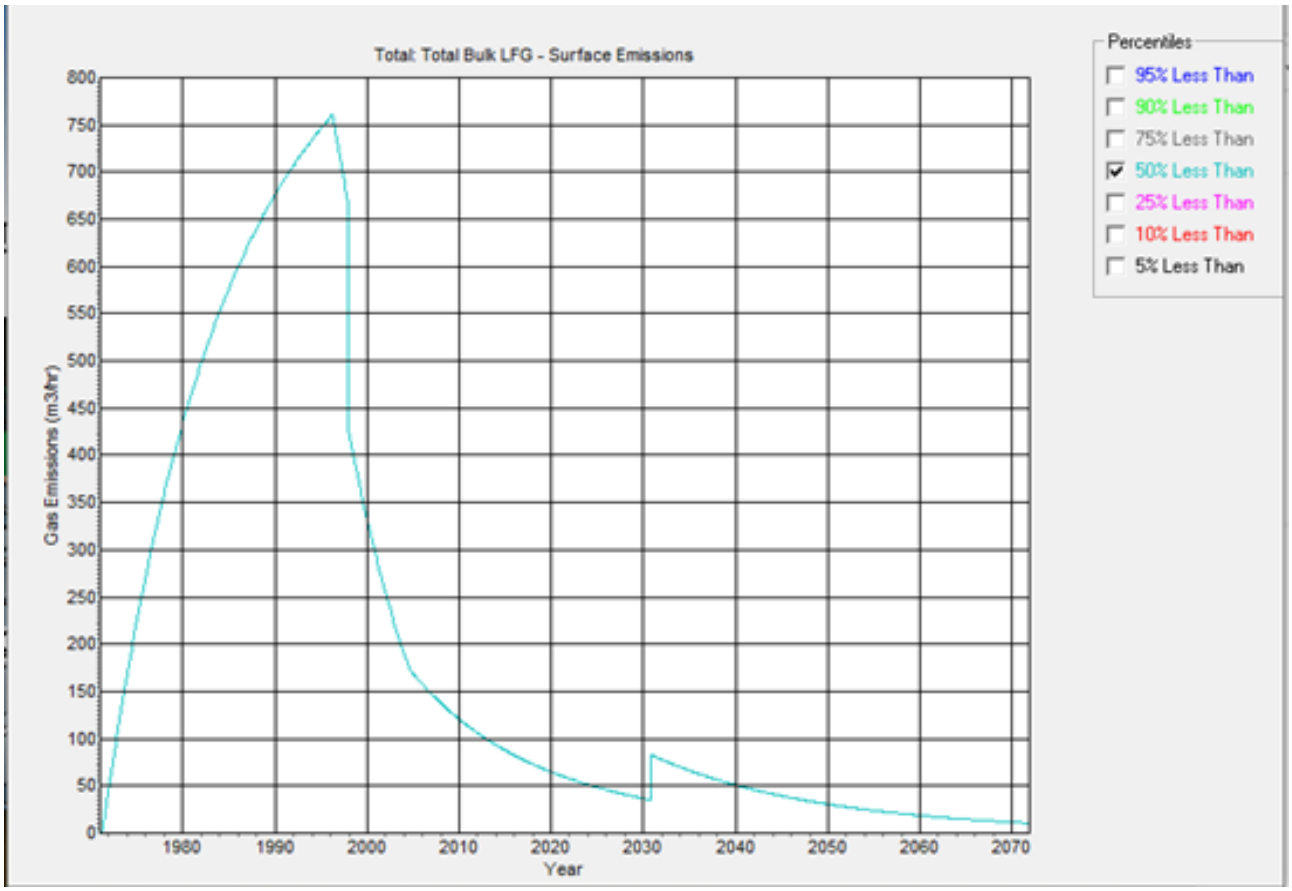
The model validation is demonstrated in Figure 3.4.

4.4 Risks to the Environment and Human Health

4.4.1 Landfill Gas Emissions

Surface emissions were identified to be tailing off considerably from a peak of 750m^3/hr in 1996 to approximately 70m^3/hr at present. This is expected to fall further to less than 50m^3/hr by 2030. The step in the graph shown in Figure 4.1 represents the anticipated completion of gas extraction for power generation. The model does not include the installation of a low methane, low flow gas flare and therefore the step would probably not be incurred if this were to be installed.

Figure 4.1: Surface emissions recorded in GasSim [8]



Lateral emissions have not been recorded.

4.4.2 Sub-surface Migration and Vegetation Stress

The impact of bulk gases lateral migration to vegetation in 2021 from waste deposited at the site was assessed and no lateral migration was anticipated. This appears to be borne out by evidence on site, where no die-back can be observed.

4.4.3 Atmospheric Dispersion and Odour

A tier 1 screening assessment was undertaken using the relevant feature of the GasSim programme. GasSim uses, as its base, the Environment Agency Guidance "Screening Method for Emissions to Air from Landfill Sites", 2004. This calculates the ground level concentration of a gaseous emission at a receptor, based on the 95%ile emission rate from the process, its height and the distance to the receptor.

Gaseous emissions to air are considered insignificant and therefore do not require further detailed modelling if:

- long term ground level contributions at the receptor are below 1% of the long-term Environmental Assessment Level (EAL) or Environmental Quality Standard (EQS); and
- short term contributions are below 10% of the short-term EAL or EQS.

[8] The slight increase in gas emissions relates to the anticipated end date modelled for viable gas utilisation.

The assessment considered the impact of various compounds including oxides of nitrogen (NO_x) and sulphur dioxide. It identified that detailed monitoring was not required for any parameter from 2021 onwards for either the short term or the long-term situations.

5 Conclusions

The wider site encompassing the licensed facility and wastes deposited in the 1970s have the potential to generate methane and carbon dioxide at concentrations that would form a risk to properties in the vicinity. The potential risks should be reducing as gas generation has reduced significantly since the waste was first deposited.

Observation wells were installed alongside the gas extraction system, but these have all been installed in wastes. (See a summary of the driller's logs in Appendix C). As a result, all boreholes would be subject to the influence of landfill gas within the vicinity. In the wider perspective, the whole area appears to have been subject to various degrees of filling over the past century and therefore establishing the influence of the wastes deposited since the 1970s is unlikely to be possible. It is considered that expanding the gas monitoring regime to include wells already installed or through installing new purpose-designed wells would not provide any greater information over the risk observed from the deposited materials in the vicinity. As a result, it is not proposed to provide a regular increase in either monitoring frequency or location, or to set threshold trigger levels for the existing locations.

Any development with this area, therefore, has to be considered to be at risk from the impacts of gas and measures should be taken during new construction to ensure that gas control measures are incorporated into the designs. It would appear that this approach has been in place for several decades.

Gas is extracted for power generation. This should continue for as long as it is possible to extract value. To this extent, the Council has recently commissioned RPS to continue the role that had previously been undertaken by Infinis.

In recent years, the extraction system wells and manifolds have been monitored at quarterly intervals. This should continue. Providing additional monitoring to that already provided is unlikely to be informative.

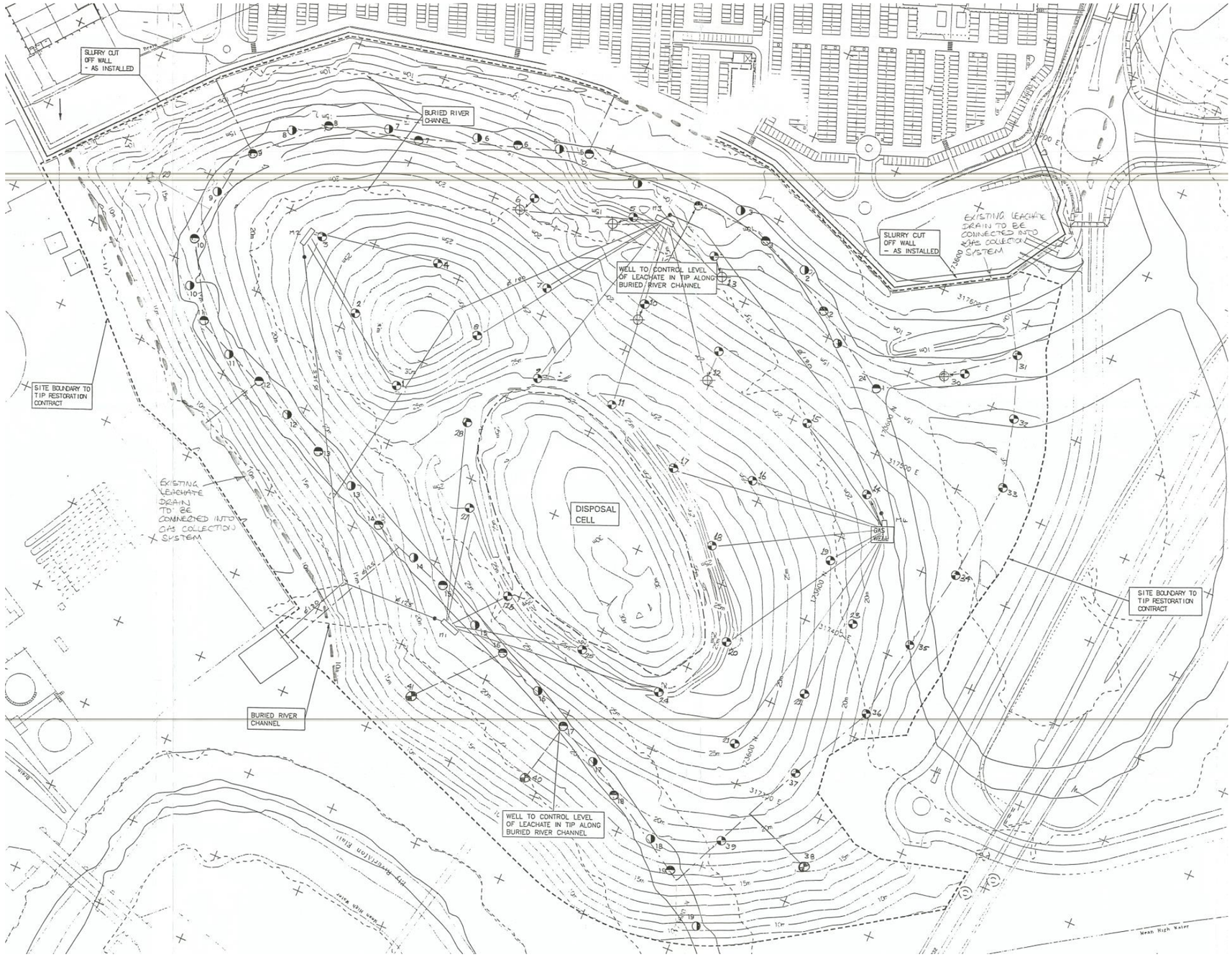
Once power generation is unproductive, it will be necessary to install a low methane, low flow gas flare. Extraction should continue for as long as feasible. Beyond this time, consideration should be given to undertaking active venting without flaring.

This risk assessment should be reviewed either within the next six years, as is typically required, or should extraction system cease, whichever is earlier.

A. Gas extraction well location plan

The following is an extract from plan “Ferry Road – Licenced tip restoration civil engineering works – Layout of leachate, gas and observation wells – Drawing Number WSK125”, Over Arup & Partners, January 1997.

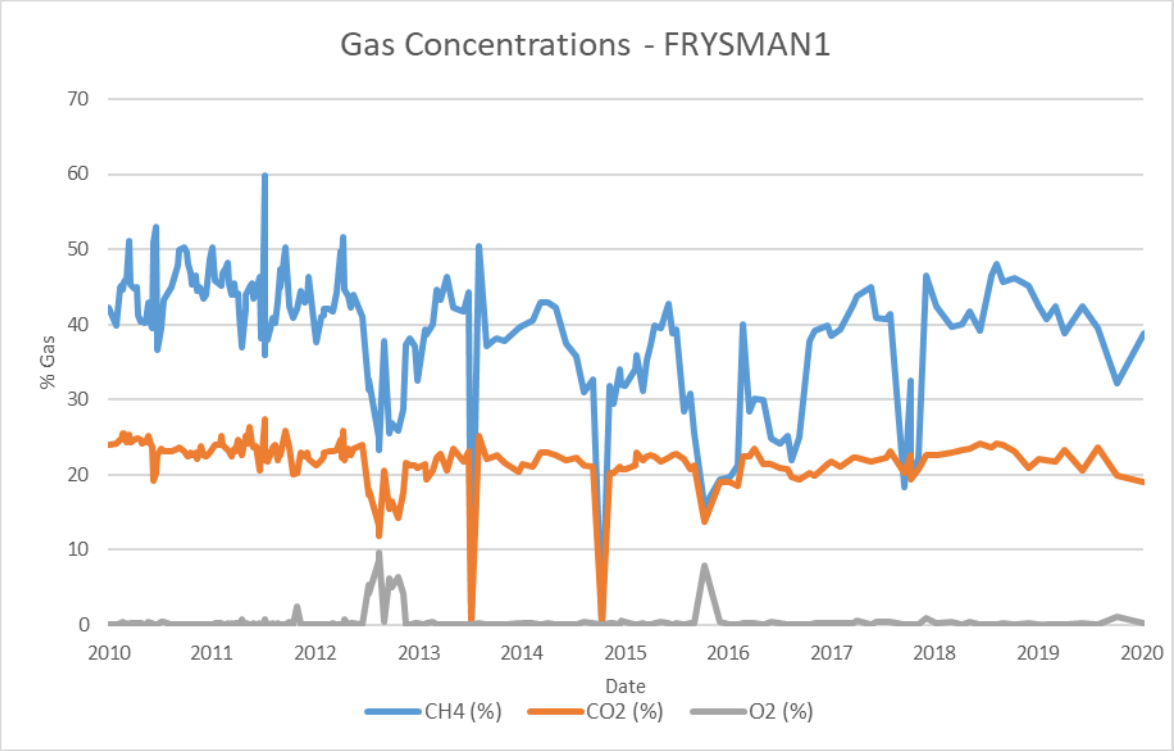
Figure A.1: Extract of plan showing gas extraction wells and manifolds



Source: "Ferry Road – Licenced tip restoration civil engineering works – Layout of leachate, gas and observation wells – Drawing Number WSK125", Over Arup & Partners, January 1997

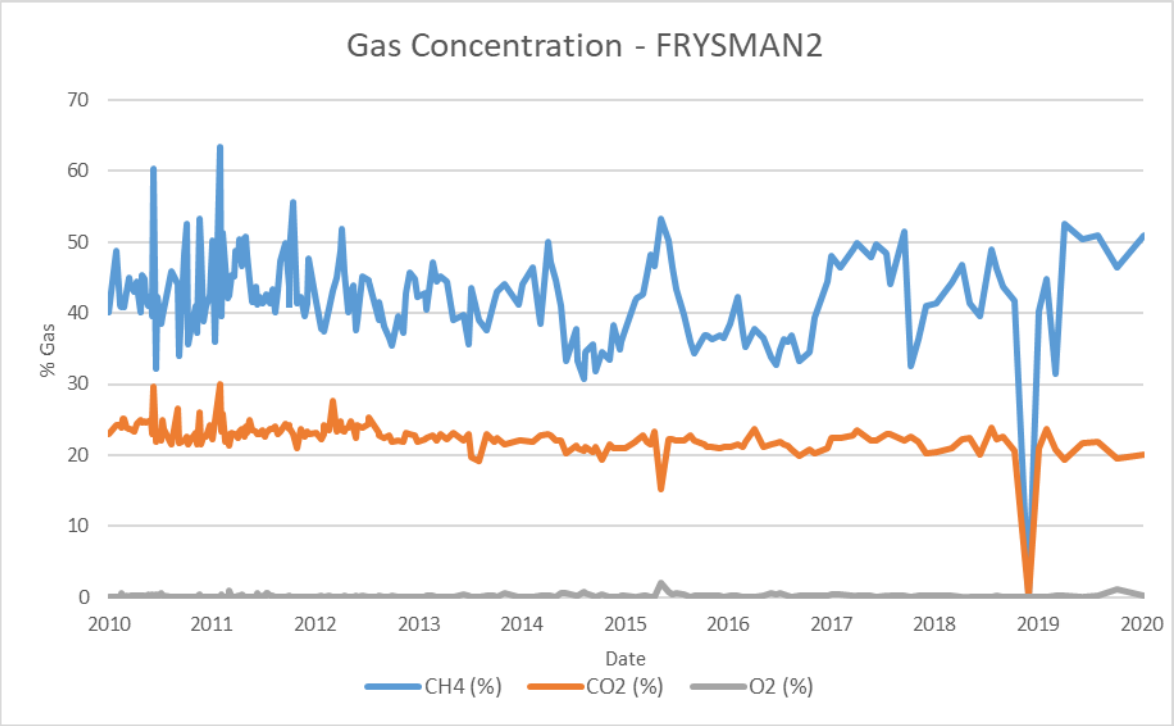
B. Graphical representation of monitoring results from the gas manifolds

Figure B**.1:Gas Concentrations – Manifold 1**



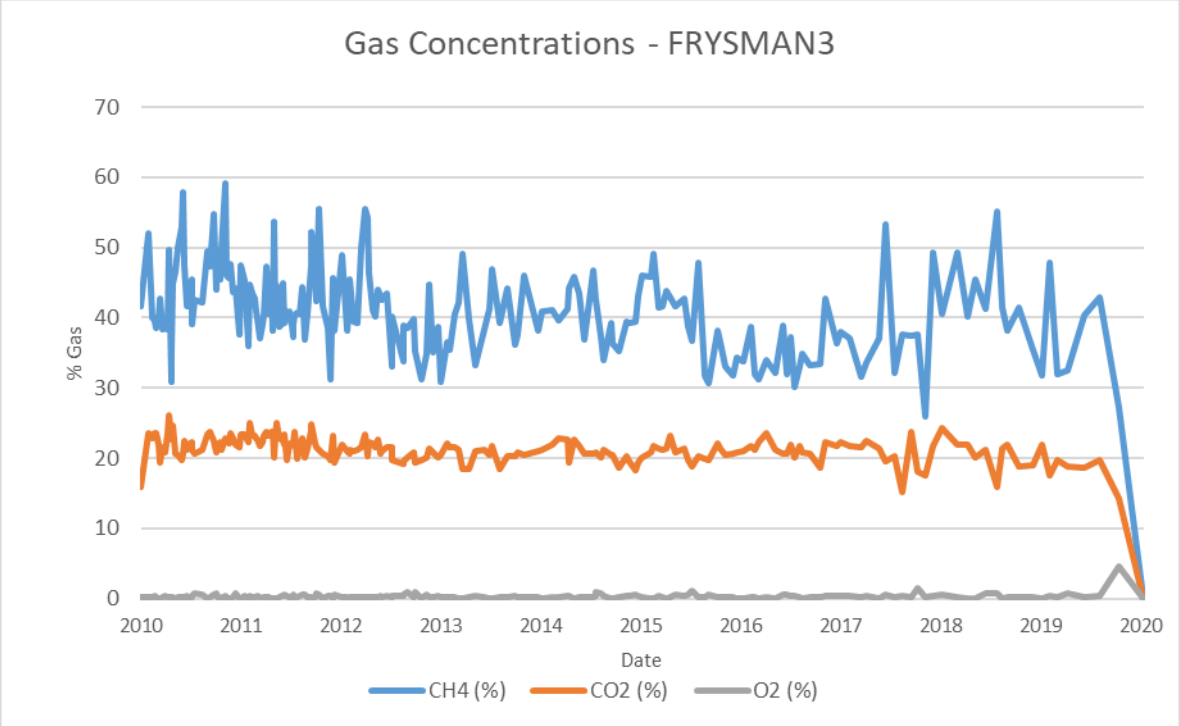
Source: Infinis

Figure 5.2: Gas Concentrations – Manifold 2



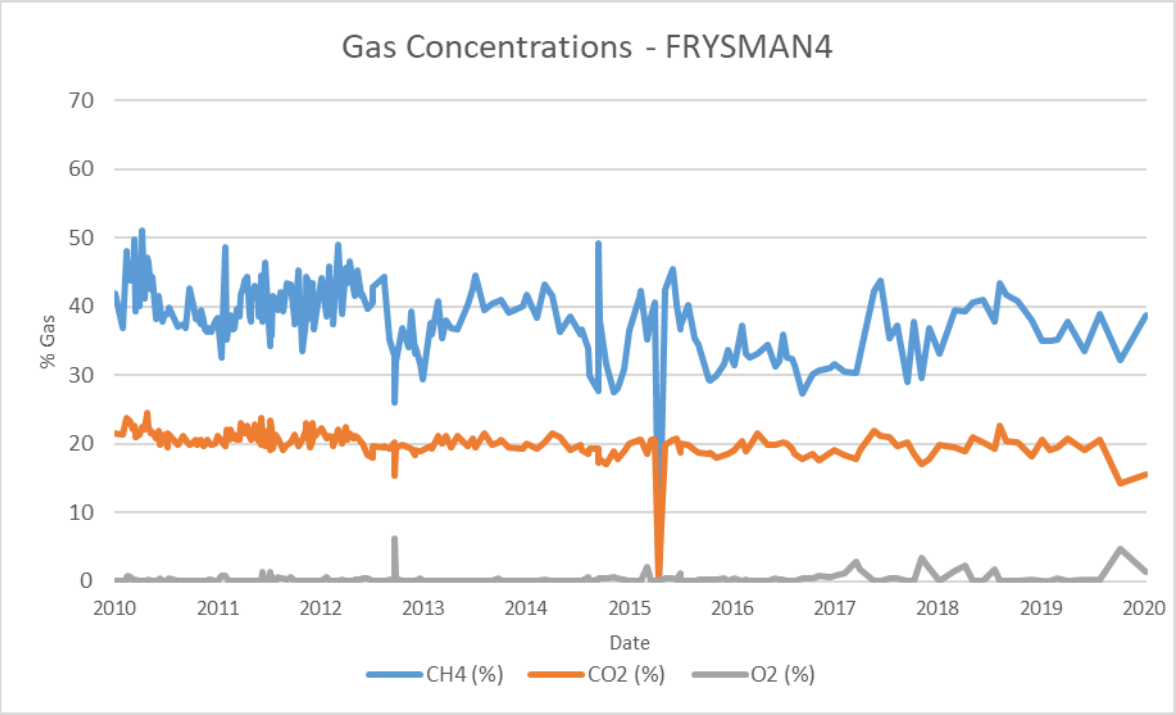
Source: Infinis

Figure B.3: Gas Concentrations – Manifold 3



Source: Infinis

Figure B.4: Gas Concentrations – Manifold 4



Source: Infinis

C. Driller’s logs

Table C.1: Drillers logs for observation wells

Reference	Easting	Northing	Ground Level AOD	Base level AOD	Top Level AOD	Base Level AOD	Length (m)	Top Level AOD	Base Level AOD	Length (m)	GW level AOD	Geology description
OW2	317577.464	173675.351	12.2	-1.109	11.487	7.487	4	7.487	-0.363	7.85	Unsure	1.0m marl and then waste to toe
OW3	317596.558	173721.627	9.9	-1.216	10.442	6.442	4	6.442	-0.658	7.1	Unsure	0.5m marl and then waste to toe
OW4	317586.708	173779.640	12.7	-0.134	11.851	7.851	4	7.851	-0.449	8.3	5	3.0m marl and then waste to toe
OW5	317561.121	173783.372	13.3	-1.196	13.14	9.14	4	9.14	-0.81	9.95	Unsure	1.0m marl and then waste to toe
OW6	317575.902	173873.286	15.4	-1.2	15.589	11.589	4	11.589	-0.761	12.35	Unsure	1.0m marl and then waste to toe
OW7	317562.340	173917.583	16.5	-1.257	16.654	12.654	4	12.654	-0.696	13.35	5	1.0m marl and then waste to toe
OW9	317492.803	173991.865	18.6	-1.21	18.78	14.78	4	14.78	-0.77	15.55	Unsure	1.0m marl and then waste to toe
OW11	317411.875	173950.777	17.0	-1.265	16.576	12.576	4	12.576	-0.724	13.3	Unsure	1.0m marl and then waste to toe
OW12	317393.153	173907.691	18.7	-1.223	18.51	14.51	4	14.51	-1.04	15.55	Not identified	1.0m marl and then waste to toe
OW13	317370.686	173859.516	19.6	-1.139	19.325	15.325	4	15.325	-0.925	16.25	Unsure	1.0m marl and then waste to toe
OW14	317347.305	173812.139	21.1	-1.21	21.627	17.627	4	17.627	-0.673	18.3	Unsure	1.0m marl and then waste to toe
OW15	317325.063	173765.528	23.1	-1.156	23.716	19.716	4	19.716	-0.884	20.6	Unsure	1.0m marl and then waste to toe
OW16	317305.692	173720.595	21.9	-1.222	21.739	17.739	4	17.739	-0.161	17.9	Unsure	1.0m marl and then waste to toe
OW17	317281.183	173677.185	21.6	-1.288	20.024	16.024	4	16.024	-0.856	16.88	Unsure	2.0m marl and then waste to toe
OW18	317253.370	173631.571	19.6	-1.169	19.178	15.178	4	15.178	-1.092	16.27	Not identified	2.0m marl and then waste to toe
OW19	317218.089	173589.993	13.6	-1.238	11.495	7.495	4	7.495	-1.015	8.51	Unsure	2.0m marl and then waste to toe

Source: Drillers' logs VHE Construction Ltd

Table C.2: Drillers logs for gas wells

Reference	Easting	Northing	Ground Level AOD	Base level AOD	Top Level AOD	Base Level AOD	Length (m)	Top Level AOD	Base Level AOD	Length (m)	GW level AOD	Geology description
GW1	317432.196	173858.305	26.6	3.65	27.935	23.435	4.5	23.435	4.245	19.19	Unsure	Waste to toe
GW2	317460.522	173894.963	27.0	3.673	27.832	23.332	4.5	23.332	4.302	19.03	Unsure	Waste to toe
GW3	317492.518	173928.502	23.1	23.1	23.38	18.88	4.5	18.88	4.78	14.1	Dry	1.0m marl and then waste to toe
GW4	317503.949	173863.811	29.2	3.733	27.707	23.207	4.5	23.207	4.207	19	Unsure	2.3m marl and then waste to toe
GW5	317561.121	173783.372	16.1	3.603	16.24	11.74	4.5	11.74	4.32	7.42	5.1	1.0m marl and then waste to toe
GW6	317548.828	173833.792	19.6	3.799	19.256	14.756	4.5	14.756	4.356	10.4	Unsure	3.0m marl and then waste to toe
GW7	317514.063	173800.626	23.2	3.786	23.604	19.104	4.5	19.104	4.454	14.65	Unsure	3.0m marl and then waste to toe
GW8	317475.556	173828.406	30.6	3.73	29.672	25.172	4.5	25.172	4.242	20.93	Unsure	2.0m marl and then waste to toe
GW9	317466.357	173788.184	23.6	3.651	24.173	19.673	4.5	19.673	4.223	15.45	Unsure	1.0m marl and then waste to toe
GW11	317470.322	173241.950	25.1	3.34	25.625	21.125	4.5	21.125	4.345	16.78	Not identified	Not identified
GW12	317500.816	173694.129	21.1	3.73	20.991	16.491	4.5	16.491	4.191	12.3	Dry	1.0m marl and 14.87m waste, then clay to toe
GW13	317557.889	173715.536	14.2	3.5	14.059	10.559	3.5	10.559	4.459	6.1	Unsure	1.0m marl and then waste to toe
GW16	317460.048	173656.890	24.3	3.9	24.381	19.881	4.5	19.881	4.421	15.46	5.9	1.0m marl and 17.5m waste, then clay to toe
GW18	317420.413	173658.970	28.2	3.367	28.505	24.005	4.5	24.005	4.315	19.69	Dry	2.5m marl then waste to toe
GW19	317435.863	173599.924	22.4	3.714	22.033	17.533	4.5	17.533	4.133	13.4	Unsure	1.0m marl and 15.7m waste, then clay to toe
GW20	317371.944	173634.846	28.1	2.321	28.513	24.013	4.5	24.013	4.183	19.83	Unsure	0.2m marl then waste to toe
GW21	317320.934	173609.385	25.2	3.744	25.357	20.857	4.5	20.857	4.297	16.56	Unsure	2.0m marl and 16.8m waste, then clay to toe
GW22	317361.723	173584.368	23.1	3.729	23.248	18.748	4.5	18.748	4.368	14.38	Unsure	2.0m marl and 13.9m waste, then clay to toe
GW23	317407.985	173574.940	19.6	3.725	20.488	15.988	4.5	15.988	4.038	11.95	Unsure	1.0m marl and then waste to toe
GW24	317326.734	173658.103	26.8	1.671	27.231	22.731	4.5	22.731	4.271	18.46	Unsure	0.2m marl then waste to toe
GW25	317328.672	173210.209	25.9	1.505	26.389	22.889	3.5	22.889	4.329	18.56	Unsure	0.2m marl then waste to toe
GW26	317344.876	173758.238	26.1	2.42	26.567	22.067	4.5	22.067	4.187	17.88	Unsure	0.2m marl then waste to toe
GW28	317381.858	173799.182	23.8	3.712	23.686	19.186	4.5	19.186	4.226	14.96	Not identified	1.0m marl and then waste to toe
GW29	317481.910	174033.746	16.0	3.927	15.021	11.521	3.5	11.521	4.411	7.11	Unsure	2.0m marl and then waste to toe

Source: Drillers' logs VHE Construction Ltd

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