Appendix E
Landfill Gas

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Appendix E1

Landfill Gas Background

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1 Key Source of Information

The following key sources of information were used in this assessment:

- Rosedale LFG Annual Report, ESL, May 2016
- Air Quality Management Plan: Rosedale Closed Landfill, URS, July 2015
- Assessment of Air Quality Effects associated with the Rosedale Closed Landfill, URS, July 2013
- Rosedale Landfill Aftercare Management Plan, ESL, March 2010
- Rosedale Landfill Gas Reticulation Plan, ESL Drawing Number 125-1422-38, 28 October 2009
- Rosedale Landfill gas Collection System, ESL, September 2008
- Rosedale Landfill Aftercare Contingency Works Plan, ESL, January 2003
- Assessment of Environmental Effects of Concerning Modifications to Proposed Consent Order for Rosedale Landfill, Woodward-Clyde, 2000
- Chapter 4 Discharge of Contaminants to Land and Groundwater, Earthtech Consulting Limited, March 1995
- Personal communications with Mr Martin Ward, Auckland Station Manager, ESL

1.1 Landfill Gas Background

Landfill gas is comprised of a mixture of between 120 to 150 identified different gases (EA, 2002). By volume, Landfill gas typically contains 45% to 60% methane and 30% to 40% carbon dioxide which are referred to as being the bulk gases (along with nitrogen and oxygen). Landfill gas also includes traces of nitrogen, oxygen, ammonia, reduced sulphide compounds, hydrogen, carbon monoxide, and non-methane organic compounds (NMOCs).

Table E1 General Landfill Gas Composition

Component	Part of the total gas volume
Methane	45% to 60%
Carbon dioxide	30% to 40%
Nitrogen	1% to 10%
Hydrogen	0% to 2%
Oxygen	0% to 2%
Hydrogen sulphide	10 to 1,000 ppm
Total Non-Methane Organic Carbons (NMOC)	0 to 10,000 ppm

Most Landfill gas is produced by the bacterial decomposition, which occurs when organic waste is broken down by bacteria naturally present in the waste and soil used to cover the waste.

Landfill gases that are lighter than air (such as methane) have a natural tendency to migrate upwards, usually through the Landfill surface. Upward movement of Landfill gas can be inhibited by densely compacted waste or Landfill capping material. When the Landfill gas cannot migrate vertically, the gas tends to migrate horizontally to other areas within the Landfill or to areas outside of the Landfill. Once the Landfill gas is in the soil (either by pressure driven (advective) flow and/or diffusive flow), it can travel through the air filled spaces within the soil structure and travel for some distance away from the Landfill. In order for sustained migration to occur, there must be a significant area of gas generation to produce the large volumes of gas required to drive migration by either diffusive or advective flow (Wilson et al, 2009).

Methane is only slightly soluble in water (approximately 25 mg/L at standard temperature and pressure (STP)) and therefore methane migration via groundwater is not likely to occur (Wilson et al 2009). For example, perched groundwater layers can act as confining layers which can restrict the vertical migration of Landfill gas. Likewise, shallow groundwater can act as an effective barrier for the lateral migration of Landfill gas.

Geological conditions in and around the Landfill have a major influence on the risk of gas migration. Generally, Landfill gas off-site can migrate across distances of less than 100m (US EPA, Landfill Gas Primer, accessed 23 August 2016), but under ideal conditions (such as highly permeable material trapped between two confining layers) landfill gas can migrate across distances of over 300m. Typically, Landfill sites are surrounded by impermeable clay layers, which means that lateral migration of Landfill gas is limited and in some cases, it is less than 10m (Wilson, et al, 2009).

When Landfill gas migrates thorough the soil it undergoes chemical and physical changes such as methane oxidation into carbon dioxide, loss of volatile NMOC via sorption or degradation, and dilution with other soil gases. Therefore, the concentration of methane is expected to decrease with increasing distance as Landfill gas migrates away from the Landfill.

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Appendix E2

Landfill Gas Generation

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1 Landfill Gas Generation at Rosedale

This appendix assesses the Landfill gas generation potential at Rosedale and the likely Landfill gas generation potential when the Project is being undertaken in 2018 to 2020.

There are no accurate records on the amount and type of material which has been deposited within the Landfill, however, it has been estimated that approximately 3.3 million tonnes of refuse have been deposited within the Landfill (ESL, 2010). The material near the Project area is likely to refuse placed 32 to 37 years ago and generating less gas. The youngest part of the Landfill (and therefore the part with the greatest potential to generate landfill gas) is located on the northern (Greville Road) side of the Landfill. Monthly gas monitoring of the abstraction field undertaken by ESL shows that active gas generation is occurring mainly in the northern sections of the Landfill a minimum of approximately 100m for the Project (refer Drawing SKT-2348 in **Appendix A1**). Low volumes of Landfill gas are still being generated in other areas of the Landfill (such as around extraction probes 1008, 1009 and 1015). At such low volumes of gas generation, it is no longer economical to extract it for power generation. The refuse in the Landfill adjacent to the Project area which was placed into the Landfill in the late 1970s to mid-1980s and only extremely very low volumes of Landfill gas are being genearated in this area. As a result of the low generation rates in this area, ESL is no longer extracting any Landfill gas for this part of the Landfill for either flaring or power generation.

A first order Landfill gas model developed by the US EPA called LandGEMs (Version 3.02) has been used to estimate the total gas generation potential. In LandGEMs, methane production is assumed to be in a steady, linear decrease over time proportional to the degradation of organic matter in any given year, and the remaining fraction of organic matter from previous years (Atabi et al, 2014). Each year's waste follows a decreasing exponential trend in gas production until it is completely degraded (Atabi et al, 2014). Thus, according to these model assumptions, a gradual decline in Landfill gas would occur post-closure. The LandGEMs model used waste filling rates used in a previous LandGEMs, which was developed by ESL.

Other inputs required by LandGEMs model are L_o which is the amount of biodegradable material per tonne of waste, which is the average rate of decay of the biodegradable material within the Landfill.

The International Panel on Climate Change (IPCC, 2006) recognizes the high uncertainty and error associated with methane generation rate (K). The decay rates range from one to 50 years and even longer in Landfills located in dry, cold climates (Atabi et al, 2014).

Table E2 Values for the Methane Generation Rate (K)

Default Type	Landfill Type	K value (yr-1)	Years
US Clean Air Act	Conventional	0.05 (default)	20
US Clean Air Act	Arid Area	0.02	50
UE EPA inventory	Conventional	0.04	25
UE EPA inventory	Arid Area	0.02	50
UE EPA inventory	Wet	0.7	1.4

Site specific decay rates can be calculated using the formula below [Farideh, et al]:

$$K = 3.2 \times 10^{-5}(x) + 0.01$$

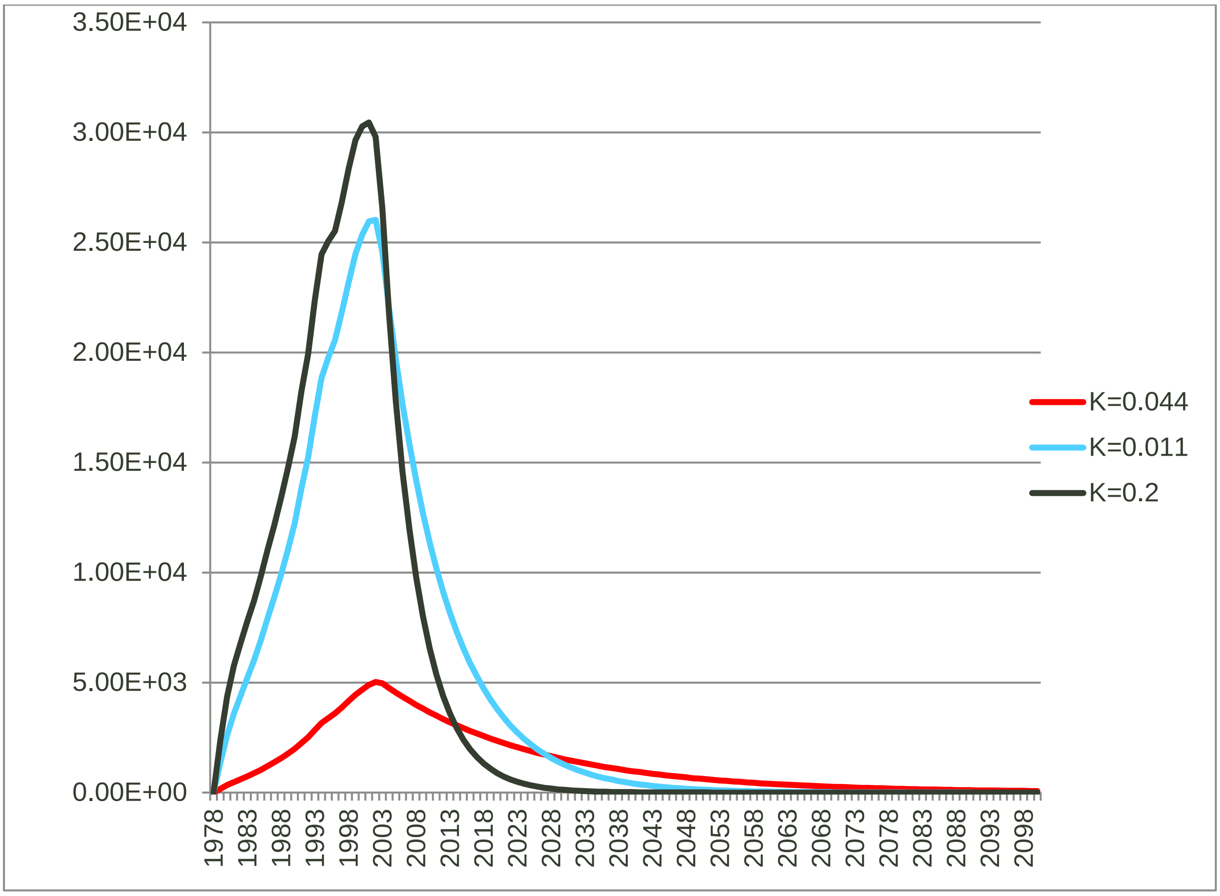
where K is a decay rate (per year), and x is an annual average precipitation for the interested period for the area where the Landfill is located.

Based on the average rainfall recorded at North Shore Albany Electronic Weather Station (EWS) (station number 37852) from 2010 to 2015, the annual average precipitation for the Landfill has been estimated as being 1052mm/yr. This would give a decay rate of approximately 0.044 per year. This calculated decay rate is very similar to the default decay rate used by LandGEMs.

Four different landfill gas generation scenarios have been modelled using LandGEMs. Historical waste acceptance rates were obtained from the Rosedale Closed Landfill Air Quality Assessment (URS, 2013). For these different scenarios a L_o of 100 m^3 of CH_4/Mg waste (this is the value used in the URS, 2013) has been used with three different values for the decay rate K=0.044 (calculated based annual average precipitation), K=0.11 (based upon the time for gas abstraction to fall to half the peak production) and K=0.2 (used in the URS, 2013).

Figure 1 shows the total landfill gas generated over time as calculated in the three different scenarios by LandGEMs. As can be seen in **Figure 1** peak gas production occurs at the Landfill in 2001 - 2002 when the Landfill closed. This is followed by a decrease in production rates. Depending on the decay rate selected in the model, the gas generation rates will drop to half the peak gas production in 2006 (K=0.02) or 2009 (K=0.011) or 2030 (K=0.044). Using decay rates based upon land site specific data (K=0.011 and K=0.02) in 2018, the gas production should decrease by a factor of 10 below the 2002 peak methane production period. Eventually, the volume of landfill gas within the Landfill will become negligible.

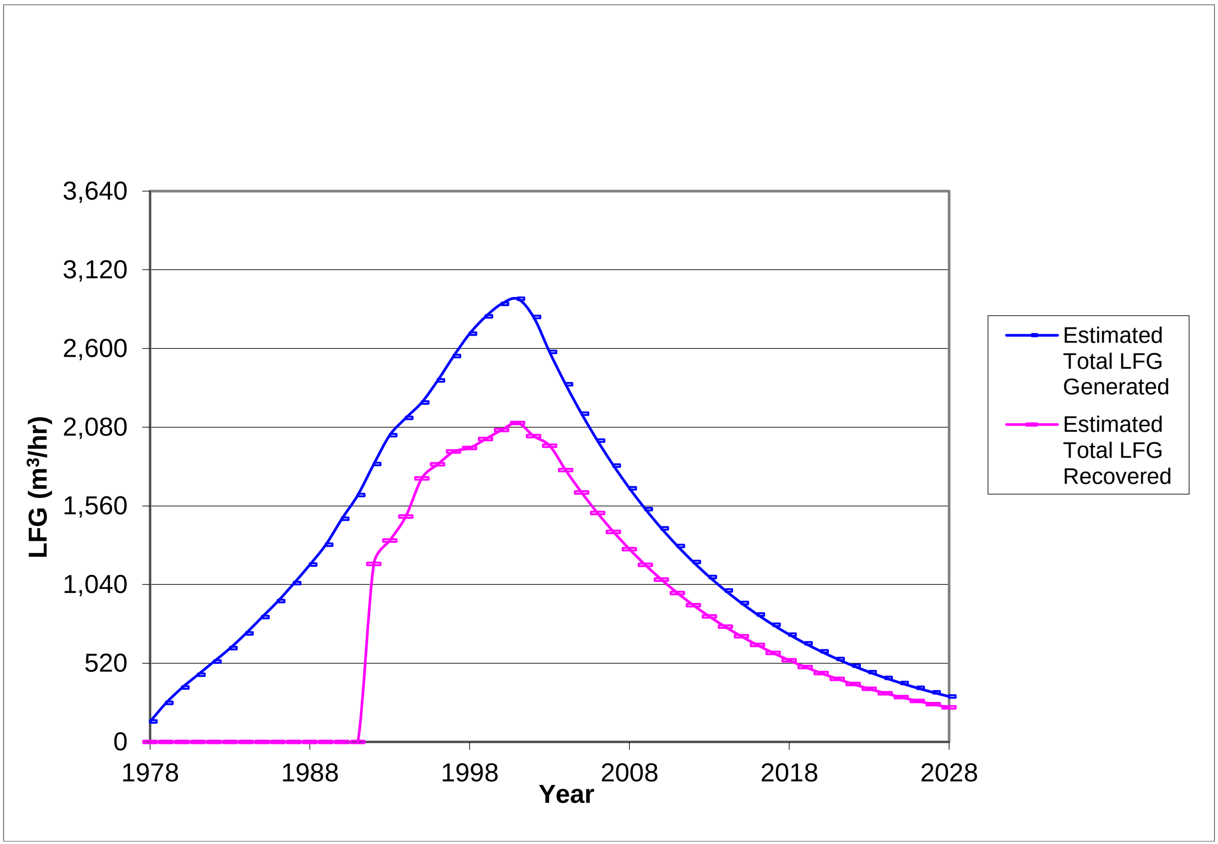
Figure 1 Total Gas Production (Mg/Year) Versus Time for Three Different Scenarios



Source: PDP

Figure 2 shows the amount of landfill gas abstraction from 1992 to 2015. It should be noted that the amount of gas extracted from the Landfill will always be less than the amount of gas generated at the site because no landfill gas extraction system will capture 100% of the gas produced.

Figure 2 **Landfill Gas Generation and Recovery in Flow Rosedale, Auckland**



Source: Auckland Council

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Appendix E3

Landfill Gas Infrastructure

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1 Introduction

The production of Landfill gas at Rosedale peaked in 2001 to 2002 at approximately 2,050m^3/hr and has decreased since this time to an estimated 170m^3/hr. It is anticipated that Landfill gas production will continue to decrease to a level where the landfill gas extraction system will also be decommissioned (potentially around 2025).

The Landfill has a landfill gas extraction system that is designed to recover landfill gas in order to minimise potential air quality impacts and manage potential risks to human health.

The Landfill gas extraction system consists of a network of gas extraction wells and connecting pipework that covers the Landfill. The gas collection network terminates at the gas compound where blower(s) are located which puts the network under vacuum in order to capture the landfill gas. The landfill gas was previously utilised to produce electricity but is now flared.

2. Gas Infrastructure

Drawing SKT-2348 in **Appendix A1** shows the current landfill gas infrastructure at the Landfill. The gas compound is located at the south-west corner of the Landfill adjacent to Rosedale Road.

2.1 Extraction Wells

As of March 2015, there were 72 landfill gas wells actively being used to extract landfill gas (refer Drawing SKT-2348 in **Appendix A1**). The majority of these wells are concentrated in the northern portion of the landfill where the last of the refuse was deposited, and where the majority of landfill gas production is occurring.

The gas wells were originally constructed at approximately 50m to 60m apart, and where required, in some areas gas wells were closer together at 25m to 50m. The wells were constructed by either drilling into the refuse in finished areas or developed 'in-situ' as the refuse cells were being constructed.

Each wellhead is connected to a well chamber which contains valves to allow tuning of the overall system in response to reticulation network changes and/or changing landfill gas generation rates.

The Landfill in the vicinity of the Project area generates very little landfill gas and is serviced by landfill gas wells that are largely not actively utilised for landfill gas management.

Table E3 below outlined the current status of gas migration probes in the vicinity of the Project area.

Table E3 Status of Gas Extraction Probes in The Vicinity of the Project area

Gas Abstraction well	Status of gas abstraction well
0001	No data- presumed closed
0024	No data- presumed closed
0027	No data- presumed closed
0028	No data- presumed closed
0029	No data- presumed closed
0030	No data- presumed closed
0031	No data- presumed closed
1008	Blocked
1009R	No data- presumed closed
1015	Blocked
1017	No data- presumed closed
1024	No data- presumed closed
1048	Open 1/4 turn
1054	Blocked
1061	No data- presumed closed
1062	No data- presumed closed
5006	Damaged

2.2 Reticulation Network

The landfill gas reticulation network is also shown in Drawing SKT-2348 in **Appendix A1**. As discussed above, the network is kept under vacuum in order to capture the produced landfill gas. The network consists of a 160mm to 200mm diameter ring main that is laid around the perimeter of the Landfill and is fed by a network of smaller diameter pipe networks that are connected to the individual landfill gas well heads.

The network comprises a mixture of MDPE, HDPE and PVC pipelines. All pipelines are installed with a fall to allow condensate to flow down to collection points and then enter the Landfill leachate recovery network. The majority of pipelines are buried under the Landfill surface to allow access for Landfill maintenance operations such as grass mowing.

2.3 Flares

There are two flares located at the gas compound; the main flare and a standby flare. This ensures redundancy for maintenance and breakdowns. The main flare is rated for volume flow rates up to 2,000m^3/hr and the standby flare is rated for up to 1,000m^3/hr. Both flares have automatic ignition systems.

2.4 Power Generation Plant (LFGTE)

As the production rate of landfill gas has decreased, the number of landfill gas engines required at the landfill has similarly decreased. The production rate of landfill gas has dropped to a level that is too low to run the landfill gas to energy and in early 2016 generation of electricity from the recovered landfill gas ceased. The landfill gas to energy plant has been decommissioned and demolished and the landfill gas extraction system has been re-tuned for the steady production of gas to feed the flares. The current landfill gas production rate is 170m3/hr.

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Appendix E4

Historic Monitoring

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1 Gas Migration Monitoring Overview

As part of the aftercare plan and consent requirements under previous resource consent 13796, gas migration monitoring probes have been installed at nominal 50m centres to a depth of between 1.5 to 4.5m around the entire boundary of the Landfill. Given the low sensitivity of the nearest receptors (commercial warehouses approximately 120 m to 150 m away) and low permeability of strata, a well spacing of approximately 50 m would meet the recommendations outlined in CIRIA C665. The locations of the monitoring probes are shown in Drawing SKT-2348 in **Appendix A1** and are identified as 21XX series.

Monthly landfill gas monitoring of migration monitoring wells along the perimeter of the Landfill is available from 2006 until 2011. More intermittent monitoring data is available from January 2012 until October 2015. From October 2015 until May 2016 monthly monitoring has resumed. Landfill gas monitoring at the Landfill has been undertaken using an infra-red gas analyser for methane, oxygen, and carbon dioxide. Atmospheric barometric pressure readings are recorded but no measurements are undertaken of gas flow or groundwater levels within the gas migration probes are undertaken. Detail logs of the geology and construction of the gas monitoring wells were unable to be located within the council's records but dipping of the monitoring wells indicates that:

- Monitoring probes 2142 to 2145 are approximately 4.5 m deep.
- Monitoring probes 2147, 2148, 2149, 2152, 2153, 2154 and 2155 are screened to the perched water table at the time of monitoring.
- Monitoring probes 2141, 2143, 2145, 2146, 2150 and 2151 – water table may be above the screen.

2 Gas Migration Monitoring Probe Data Tables

A summary of the historical monitoring data is present in **Table E4** below. Landfill gas monitoring have been undertaken during a wide range of barometric pressure but 9 of the 55 monitoring rounds have been undertaken when the barometric pressure has been 1000 hPa or less. There is no evidence of any significant relationship between barometric pressure and in-ground gas concentrations within the historical monitoring data.

Table E4 Summary of Historical Monitoring Data

Well Number	Maximum CH_4 (%)	Maximum CO_2 (%)	Minimum O_2 (%)
2101	0	2.1	17.2
2102	0	2	18.8
2103	0	3.2	16.3
2104	0	2.5	0.6
2105	0	4.1	14.2
2106	0	3	17.4
2107	0	7.2	15.2
2108	0.1	6.6	14.7
2109	0	3.8	17.3
2110	0.1	5	14.2
2111	0	3.3	17.4
2112	0	3.4	14.3
2113	0.1	2.9	16.1
2114	0.1	1.8	17.1
2115	0.1	2.5	17.6
2116	0.2	4.1	14.8
2117	0.1	2	18
2118	0.1	6.1	15.9
2119	0	4.9	13.5
2120	0	1.2	17.1
2121	0	1	18.7
2122	0	0.7	19.3
2123	0	1.3	17
2124	0	2.8	19.2
2125	0	0.6	19.9
2126	0	2.3	17.6
2127	0	6.1	12.9
2128	0.1	6.5	1
2129	0	6.4	15.4
2130	0	3.9	15.6
2131	0	3.2	17.9
2132	0	1.3	19
2133	0	0.6	19.7
2134	0	2.5	17.3
2135	0	2.5	17.1
2136	0.1	2.2	2
2137	0.3	1.6	17.8
2138	0.2	4.9	16.6
2139	0.1	4.4	9.5
2140	0.6	9.4	14

Well Number	Maximum CH_4 (%)	Maximum CO_2 (%)	Minimum O_2 (%)
2141	3.6	5.2	12.4
2142	0.1	1.5	18.1
2143	0.2	0.9	19
2144	0	0.6	19.2
2145	0	1.4	19.2
2146	0	1	19.5
2147	0	0.6	19.5
2148	0.1	0.5	19.8
2149	0	1.1	19.8
2150	0	4.9	15.7
2151	0	4.5	14.8
2152	0	4.3	15.8
2153	0	3.7	17.8
2154	0	2.1	19.5
2155	0	3.3	16.4

Historically, trace levels (less than 5%) of methane has been detected occasionally in some monitoring probes (refer **Table E5** below). Elevated levels of methane (0.1 to 3.6%) have been detected regularly in gas migration monitoring probe 2141 (at the north-western Landfill boundary) from late 2010 to 2016. On four occasions within the historical monitoring data set methane concentrations have exceeded the criteria of 1% at the boundary of the site but did not exceed the lower explosive limit of methane (approximately 5% in air).

Table E5 Monitoring Wells and Number of Detections of Methane

Well Number	Maximum CH_4 (%)	Number of times CH_4 detected	Percent time methane detected
2101	0	0	0
2102	0	0	0
2103	0	0	0
2104	0	0	0
2105	0	0	0
2106	0	0	0
2107	0	0	0
2108	0.1	1	1
2109	0	0	0
2110	0.1	1	1
2111	0	0	0
2112	0	0	0
2113	0.1	1	1
2114	0.1	1	1
2115	0.1	1	1
2116	0.2	5	7

Well Number	Maximum CH_4 (%)	Number of times CH_4 detected	Percent time methane detected
2117	0.1	2	3
2118	0.1	3	4
2119	0	0	0
2120	0	0	0
2121	0	0	0
2122	0	0	0
2123	0	0	0
2124	0	0	0
2125	0	0	0
2126	0	0	0
2127	0	0	0
2128	0.1	2	3
2129	0	0	0
2130	0	0	0
2131	0	0	0
2132	0	0	0
2133	0	0	0
2134	0	0	0
2135	0	0	0
2136	0.1	2	3
2137	0.3	1	1
2138	0.2	1	1
2139	0.1	1	1
2140	0.6	2	3
2141	3.6	23	32
2142	0.1	1	1
2143	0.2	1	1
2144	0	0	0
2145	0	0	0
2146	0	0	0
2147	0	0	0
2148	0.1	1	1
2149	0	0	0
2150	0	0	0
2151	0	0	0
2152	0	0	0
2153	0	0	0
2154	0	0	0
2155	0	0	0

Carbon dioxide concentrations within the historical monitoring data are generally less than 5% (the typical value used within as a maximum natural concentration of carbon dioxide in soils). However, there have been several occasions where carbon dioxide concentrations of between 5% to 7% have been detected in gas migration monitoring probes 2107, 2108, 2118, 2127, 2128, 2129, 2140 and 2141 (refer **Table E6** below).

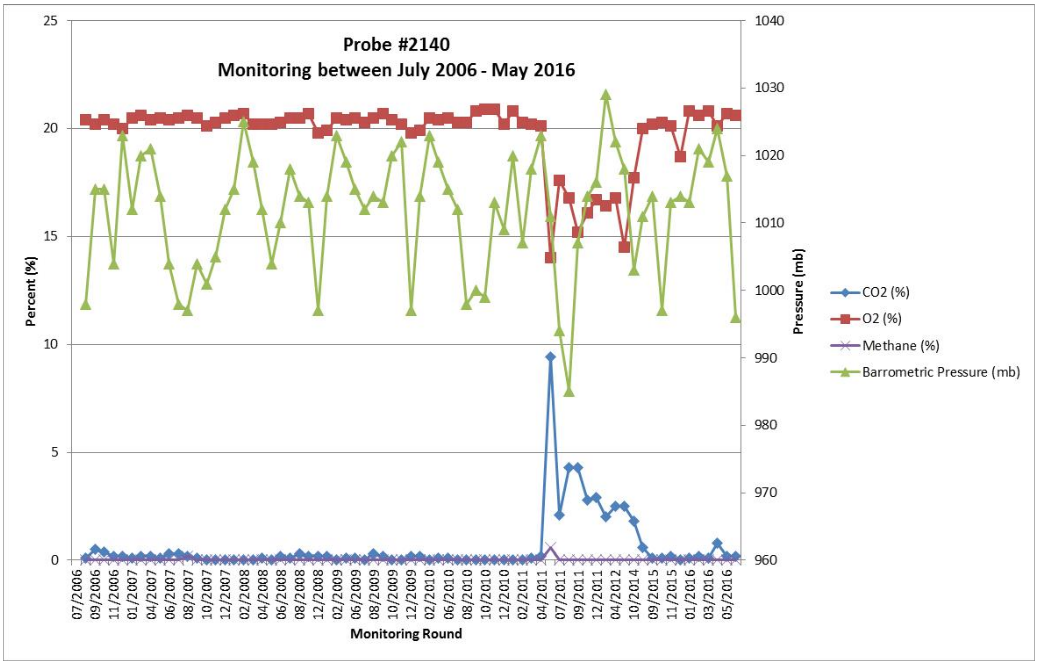
Table E6 Monitoring Wells and Number of Detections of Carbon Dioxide

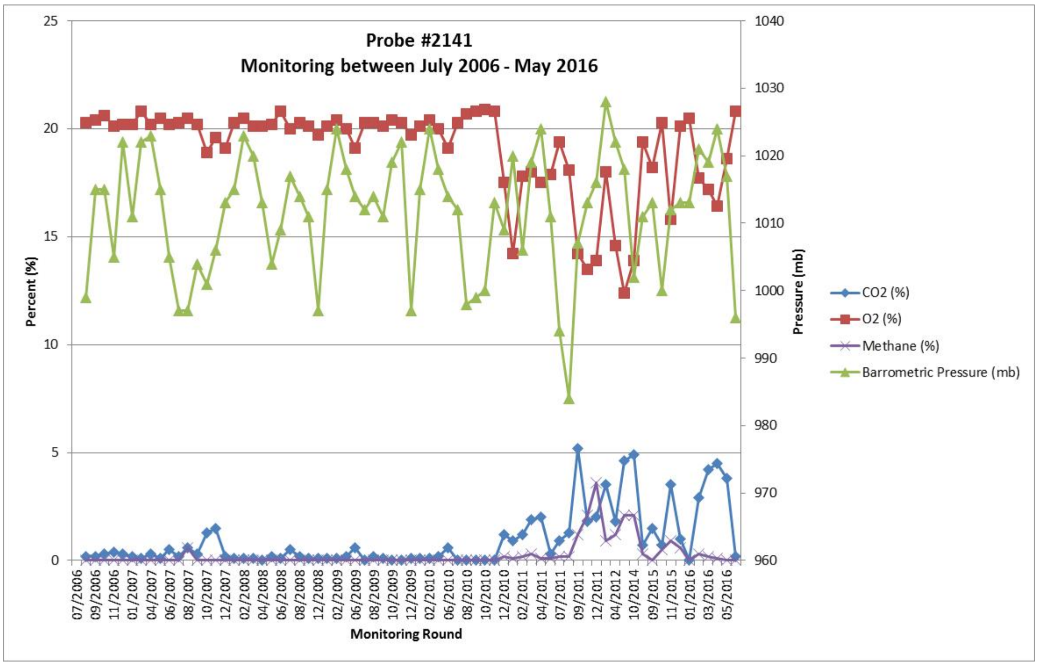
Well Number	Maximum CO_2 (%)	Number of times CO_2 detected	Percent time carbon dioxide detected
2101	2.1	29	41
2102	2	25	36
2103	3.2	33	56
2104	2.5	54	76
2105	4.1	60	85
2106	3	54	76
2107	7.2	53	75
2108	6.6	58	83
2109	3.8	52	74
2110	5	57	83
2111	3.3	59	86
2112	3.4	67	96
2113	2.9	61	87
2114	1.8	52	74
2115	2.5	56	80
2116	4.1	47	67
2117	2	51	73
2118	6.1	66	94
2119	4.9	47	84
2120	1.2	50	71
2121	1	43	61
2122	0.7	28	57
2123	1.3	44	71
2124	2.8	41	57
2125	0.6	27	90
2126	2.3	52	73
2127	6.1	39	66
2128	6.5	51	72
2129	6.4	63	89
2130	3.9	64	91
2131	3.2	64	90
2132	1.3	53	75
2133	0.6	43	61
2134	2.5	37	52

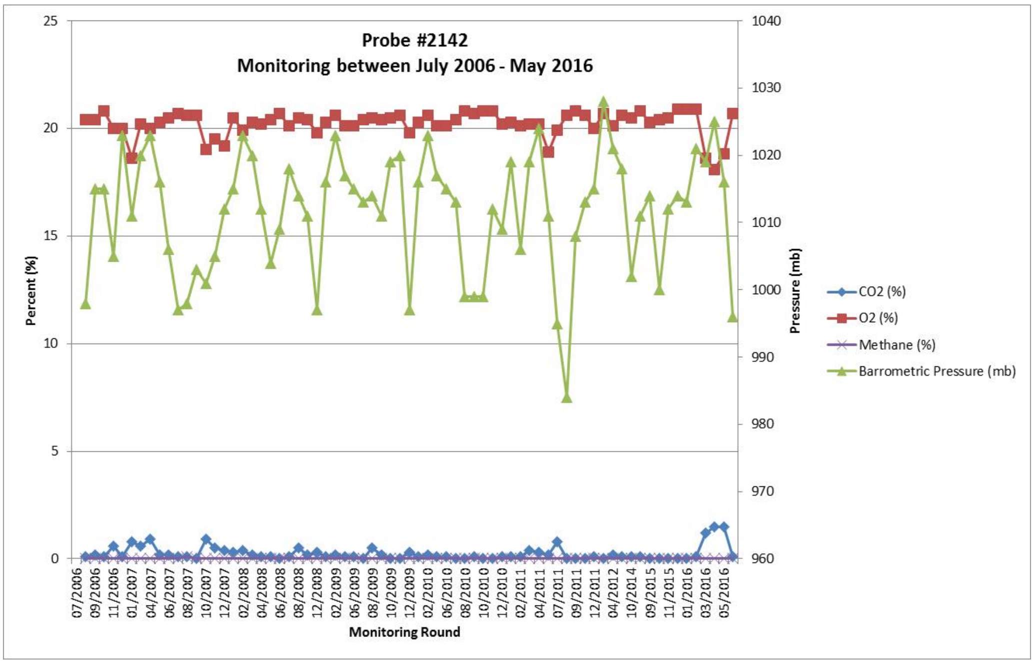
Well Number	Maximum CO_2 (%)	Number of times CO_2 detected	Percent time carbon dioxide detected
2135	2.5	33	56
2136	2.2	49	69
2137	1.6	46	65
2138	4.9	50	70
2139	4.4	46	65
2140	9.4	50	70
2141	5.2	61	86
2142	1.5	53	75
2143	0.9	49	69
2144	0.6	48	69
2145	1.4	35	50
2146	1	34	58
2147	0.6	38	54
2148	0.5	36	51
2149	1.1	38	54
2150	4.9	43	61
2151	4.5	59	83
2152	4.3	46	65
2153	3.7	48	68
2154	2.1	44	62
2155	3.3	38	54

3 Gas Migration Monitoring Probe Time Series Plots

Time series plots of the historic monitoring data for gas migration probes 2140 to 2155 are provided below.






Probe #2142
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Methane (%)
Barrometric Pressure (mb)
0
5
10
15
20
25
960
970
980
990
1000
1010
1020
1030
1040
07/2006
09/2006
11/2006
01/2007
04/2007
06/2007
08/2007
10/2007
12/2007
02/2008
04/2008
06/2008
08/2008
12/2008
02/2009
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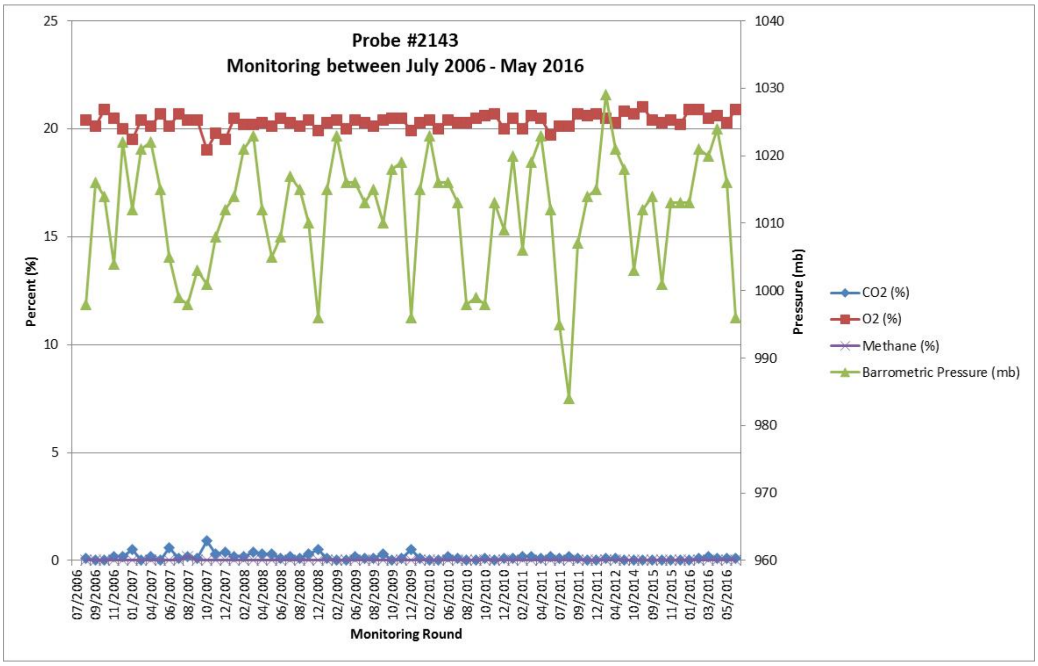
01/2016
03/2016
05/2016


Probe #2143
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Methane (%)
Barrometric Pressure (mb)
0
5
10
15
20
25
960
970
980
990
1000
1010
1020
1030
1040
07/2006
09/2006
11/2006
01/2007
04/2007
06/2007
08/2007
10/2007
12/2007
02/2008
04/2008
06/2008
08/2008
12/2008
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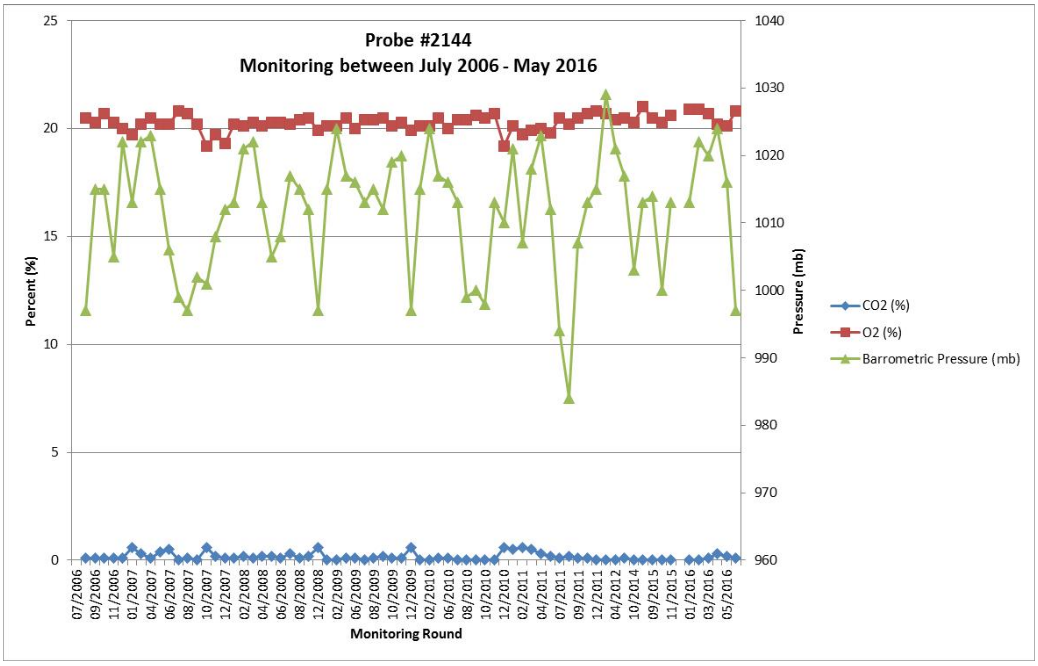
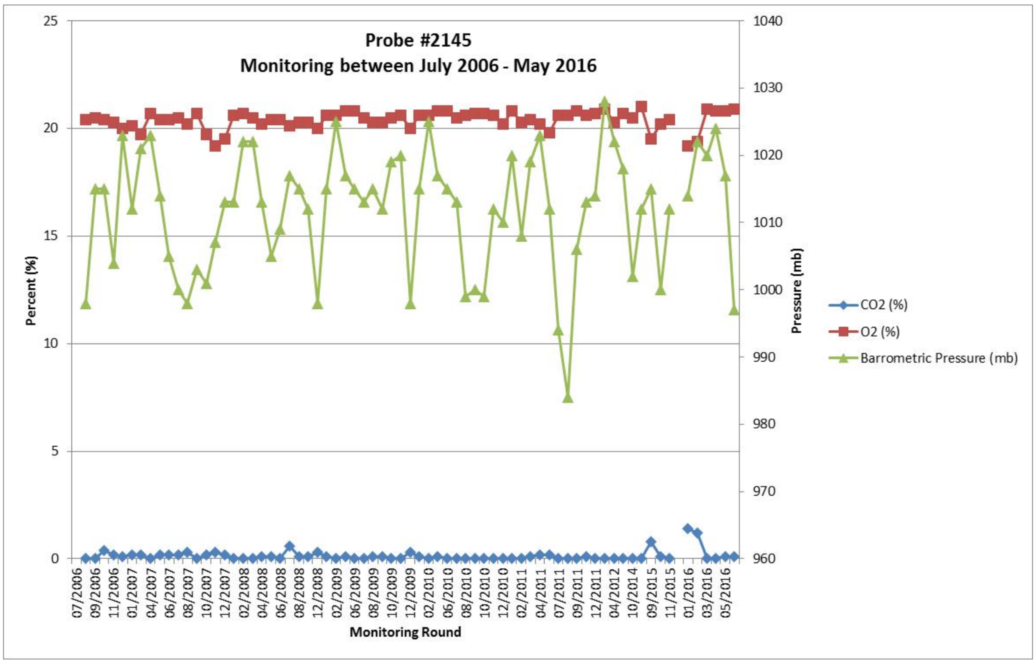
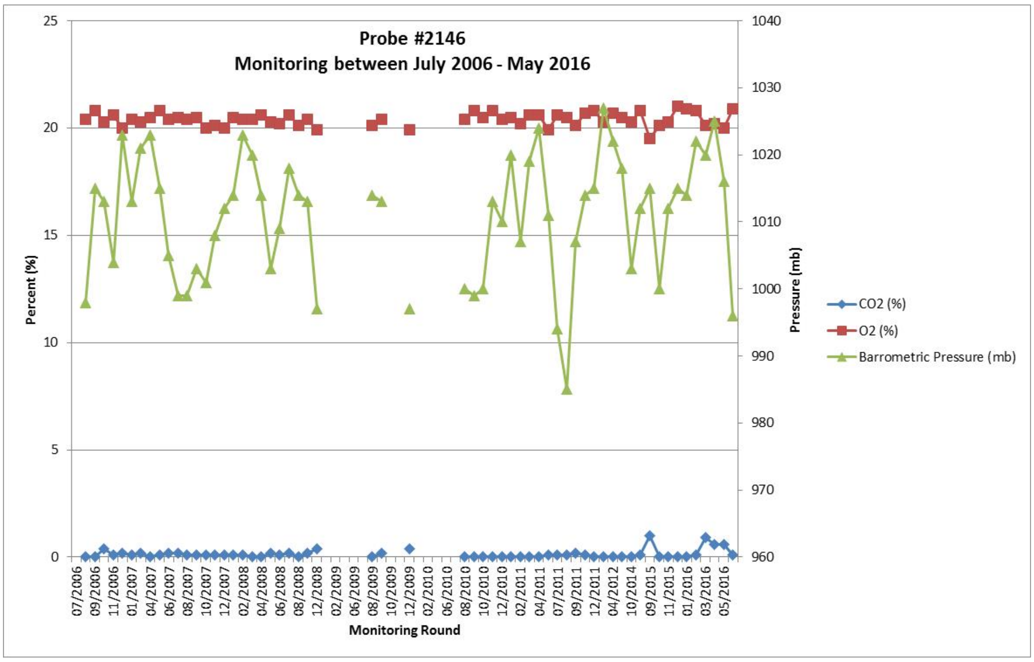
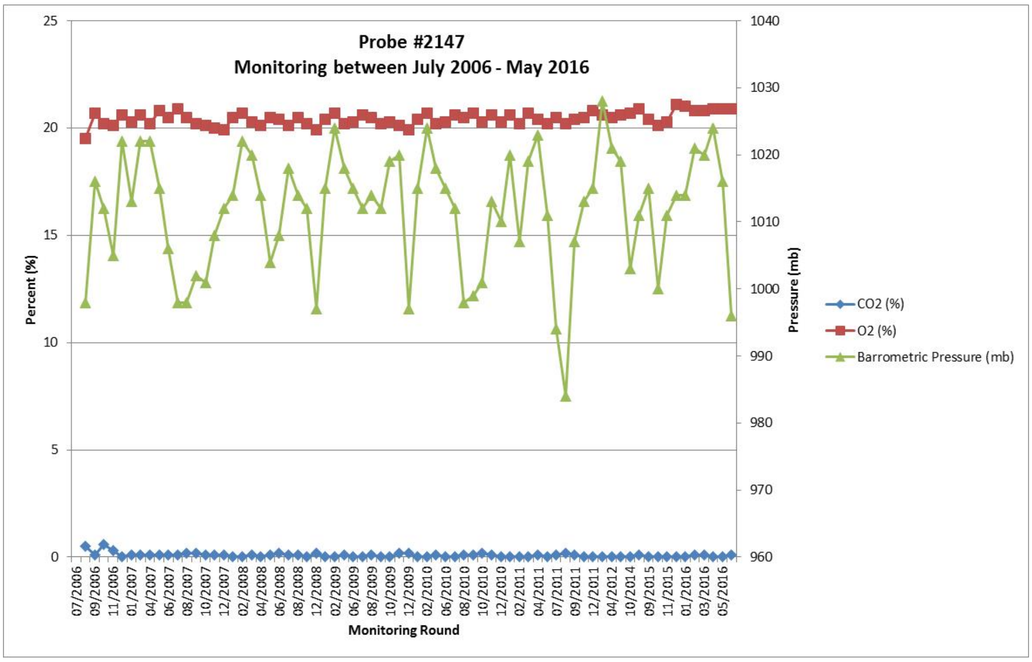
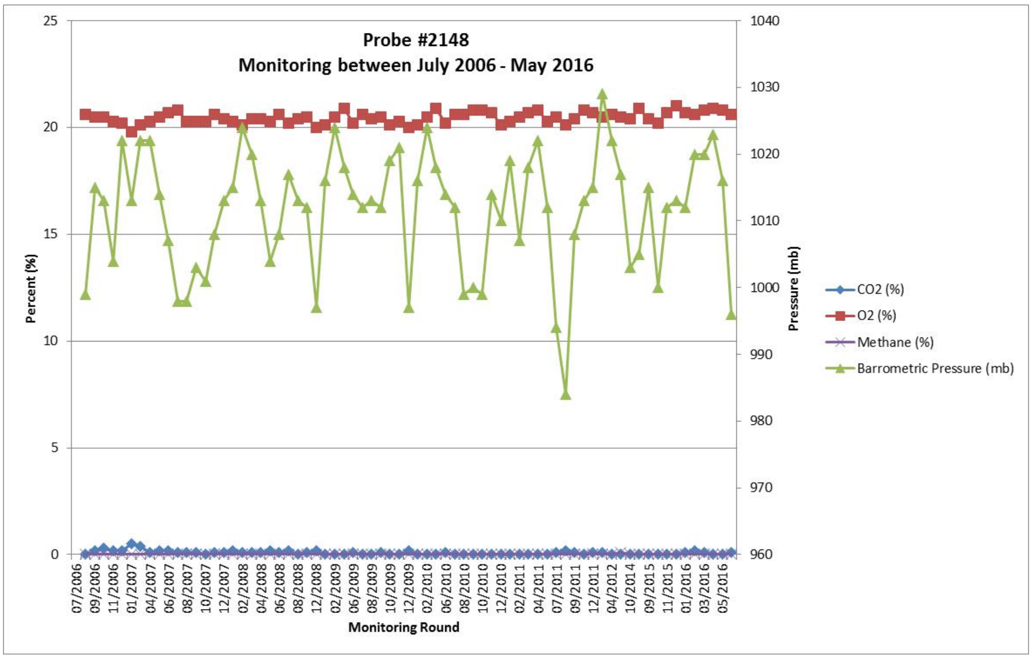
01/2016
03/2016
05/2016

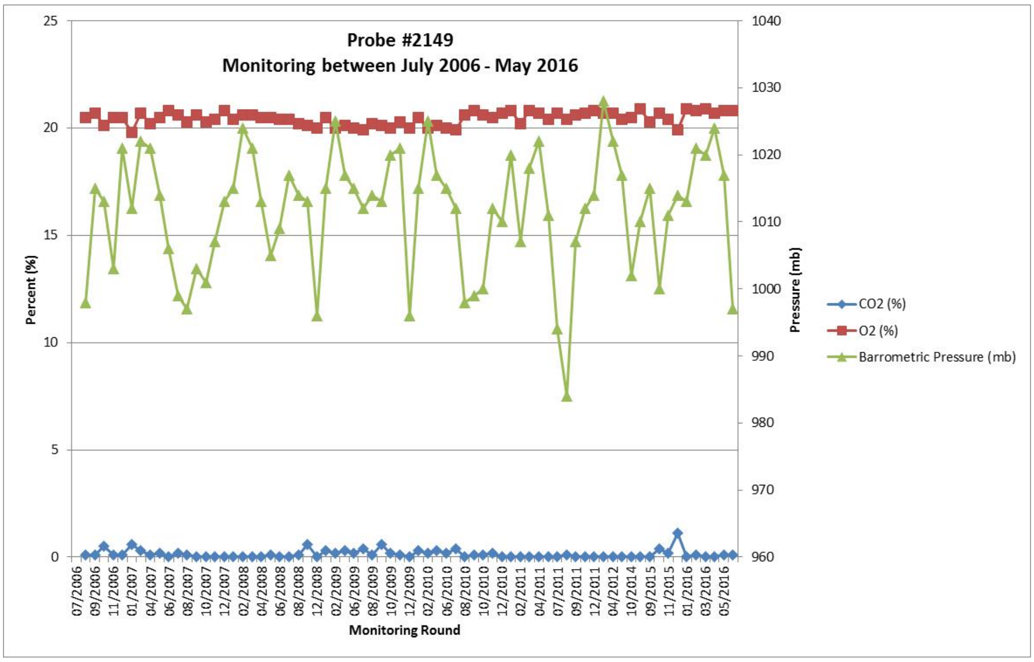

Probe #2144
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

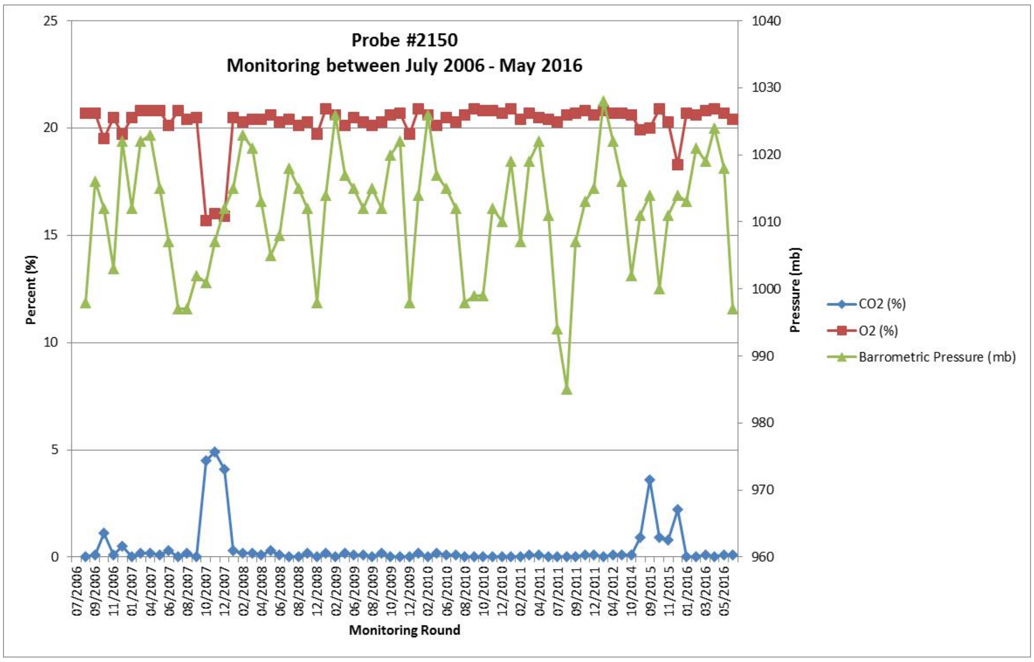

Probe #2145
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

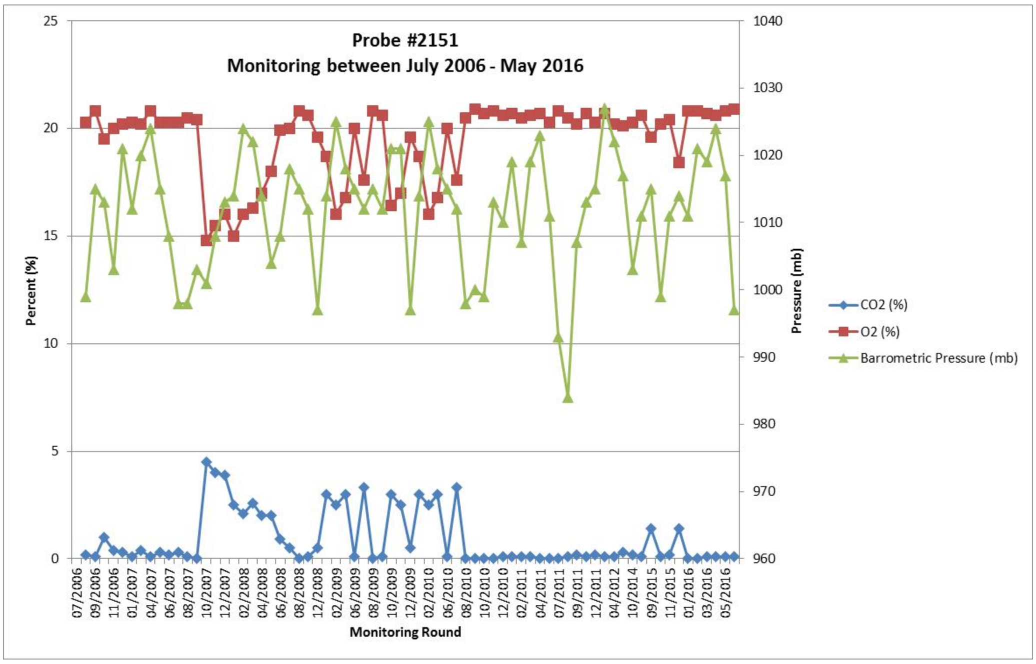

Probe #2146
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

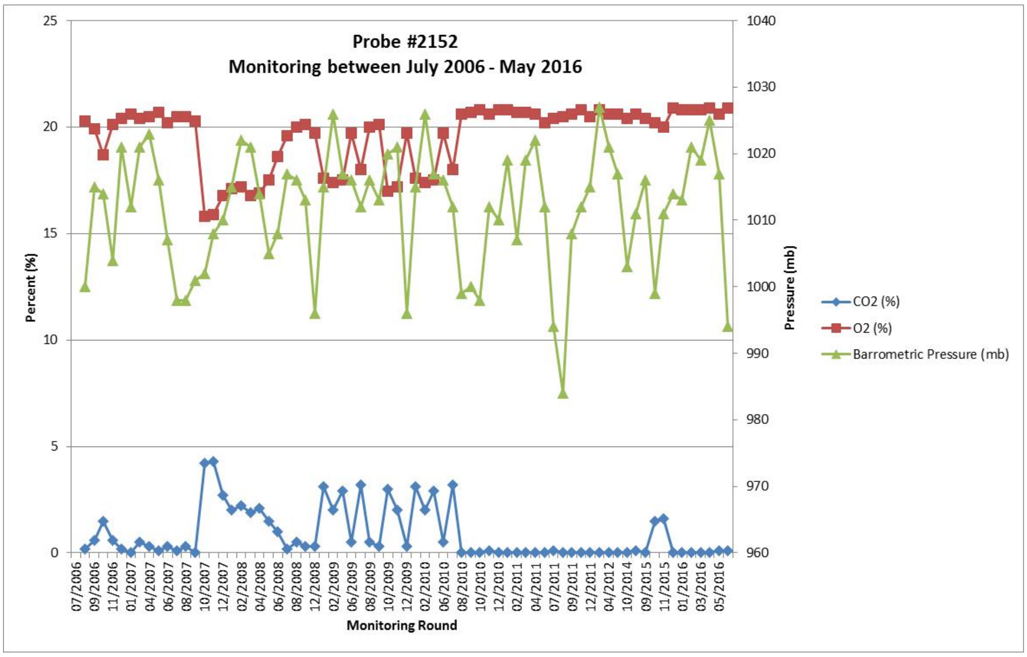

Probe #2147
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

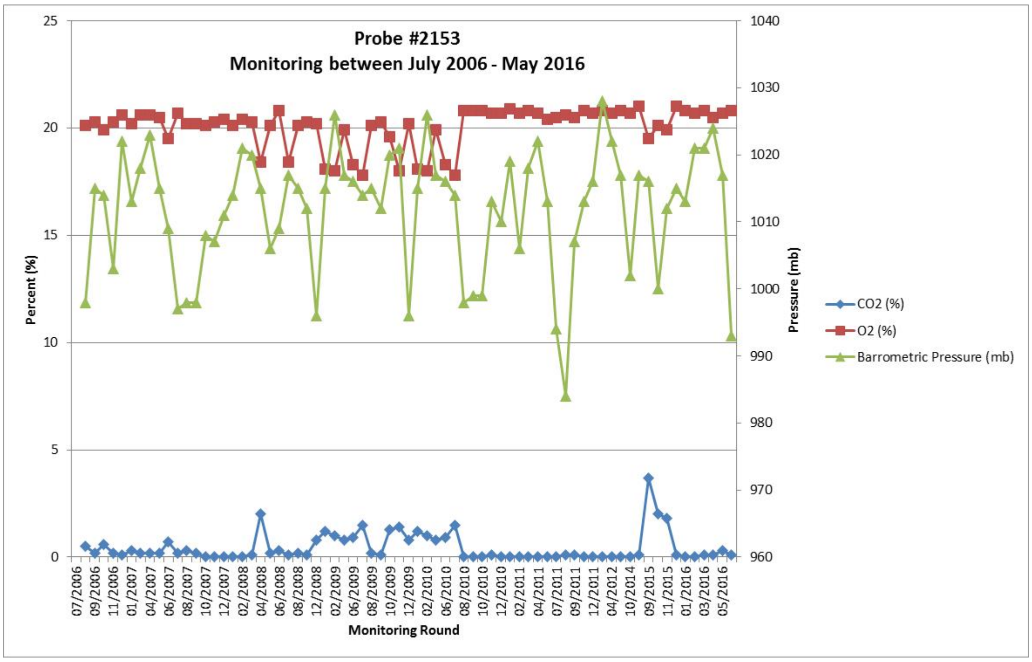

Probe #2148
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Methane (%)
Barrometric Pressure (mb)

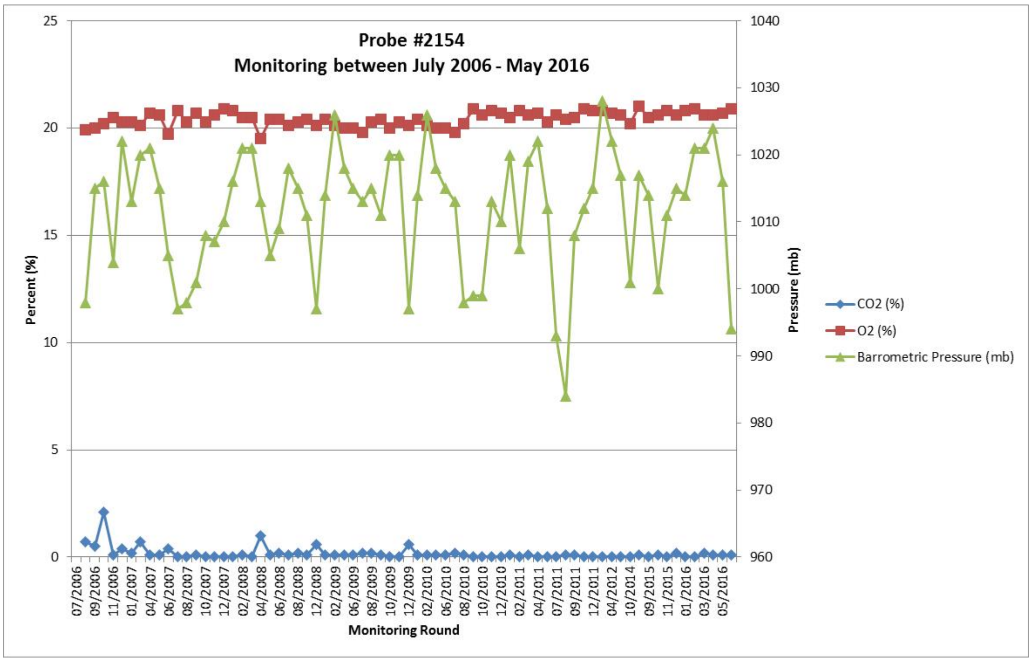

Probe #2149
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)


Probe #2150
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

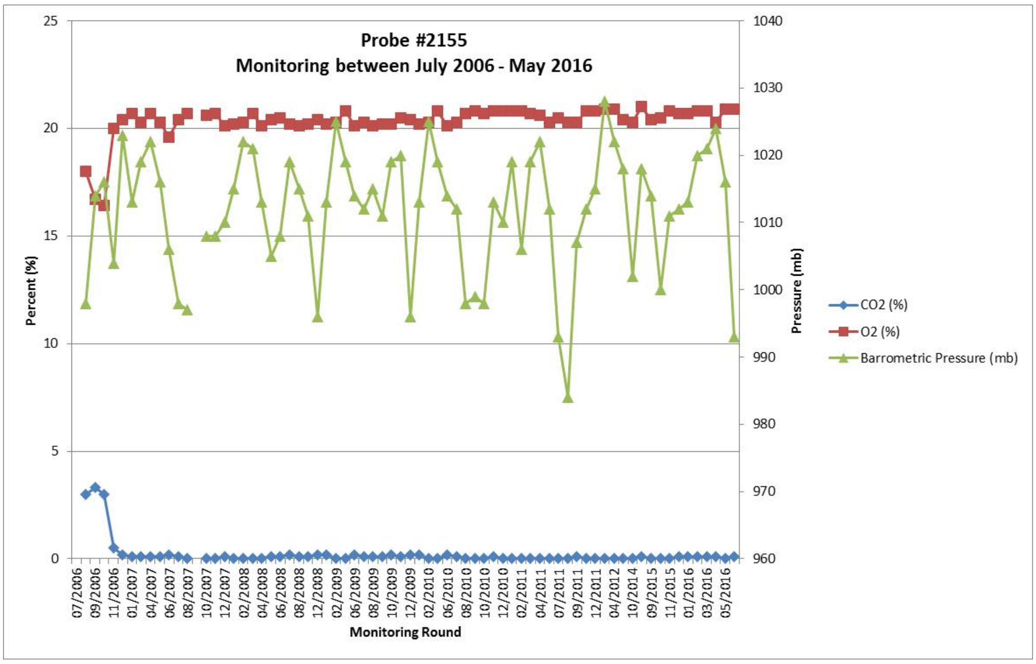

Probe #2151
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)


Probe #2152
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)


Probe #2153
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)



Probe #2154
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)



Probe #2155
Monitoring between July 2006 - May 2016
Percent (%)
Pressure (mb)
Monitoring Round
CO2 (%)
O2 (%)
Barrometric Pressure (mb)

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APPENDIX E5

PROJECT MONITORING

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1 Gas Monitoring Overview

In addition to the consent (historic) monitoring programme, Project related landfill gas monitoring was also undertaken on 9 occasions, 7 between 5 July and 12 August 2016 (refer **Table E7** below). Landfill gas monitoring was undertaken in accordance with the Project's field procedures using an infra-red gas analyser for methane, oxygen, hydrogen sulphide, carbon monoxide and carbon dioxide. Field observations and measurements were also undertaken of:

- Weather conditions for the three days before and after each monitoring event.
- The atmospheric pressure during monitoring.
- Differential pressure of the monitoring well.
- Gas flow (unit/hr).
- The water level in the monitoring well.
- Depth to the base of the monitoring well.
- The condition of monitoring well.
- Whether the gas taps have been left open or closed.

Two of the monitoring rounds, where undertaken during periods of falling barometric pressure and the pressure, were 1000 hPa (100kPa) or lower.

The results of the monitoring undertaken by the Project team are consistent with the monitoring results found by ESL which indicated that trace levels of methane are detected in monitoring probe 2141 only. No methane or evidence of landfill gas flows were found in any of the other monitoring probes.

Measurements of gas flows in migration monitoring probe 2141 detected negligible flows of landfill gas (less than 0.1 L/hr), which results in a worst case gas screening value of less than 0.04 L of methane per hour.

2 Monitoring in Gas Migration Probes

Table E7 Gas Monitoring Data from gas migration probes 2141-2155 between 08/07/2016 and 15/08/2016

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2141		**T/D: 1.61 m BTOC**								
8/07/2016										1.61
	1020	993								
	1025	993	-0.01							
	1030	993	-0.01							
	1031	993	-0.01	+0.02	0	0.2	20.6	0	0	
	1032	993	-0.01	+0.02	0	0.2	20.6	0	0	
	1033	993	-0.01	+0.02	0	0.2	20.6	0	0	
	1034	993	-0.01	+0.02	0	0.2	20.6	0	0	
	1035	993	-0.01	+0.02	0	0.2	20.6	0	0	
11/07/2016										DRY
	1124	1014	-0							

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1129	1014	-0							
	1130	1014	-0	+0.16	0	0.3	20.5	0	0	
	1131	1014	-0	+0.16	0	0.3	20.5	0	0	
	1132	1014	-0	+0.16	0	0.3	20.5	0	0	
	1133	1014	-0	+0.16	0	0.3	20.5	0	0	
	1134	1014	-0	+0.16	0	0.3	20.5	0	0	
14/07/2016										DRY
	1202	1001								
	1203	1001	-0.1							
	1204	1001	-0.2							
	1207	1001	-0.2	0	0	0.4	20.4	0	0	
	1208	1001	-0.2	0	0	0.4	20.2	0	0	
	1209	1001	-0.2	0	0	0.4	20.2	0	0	
	1210	1001	-0.2	0	0	0.4	20.2	0	0	
	1211	1001	-0.2	0	0	0.4	20.3	0	0	
	1212	1001	-0.2	0	0	0.4	20.3	0	0	
25/07/2016										DRY
	1426	1004	-0.2							
	1427	1004	-0.2	-0.2	0.1	0.4	20.1	0	0	
	1428	1004	-0.2	-0.2	0.1	0.4	20.1	0	0	
5/08/2016										DRY
	938	993	0							
	942	993	-0.14							
	947	993	-0.1							
	949	993	-0.1	-0.09	0.8	1.3	18	9	2	
	950	993	-0.1	-0.09	0.8	1.3	18	8	2	
	951	993	-0.1	-0.09	0.8	1.3	17.9	8	2	
	952	993	-0.1	-0.09	0.8	1.3	17.9	9	2	
	953	993	-0.1	-0.09	0.8	1.3	17.9	9	2	
8/08/2016										DRY
	1149	1002	-0.1							
	1154	1002	-0.1							
	1155	1002	-0.1	-0.16	0.4	6.4	10.6	0	0	
	1156	1002	-0.1	-0.16	0.4	6.3	10.7	0	0	
	1157	1002	-0.1	-0.16	0.4	6.2	10.9	0	0	
	1158	1002	-0.1	-0.16	0.4	6	11.2	0	0	
	1159	1002	-0.1	-0.16	0.4	5.8	11.5	0	0	
9/08/2016										DRY

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1227	1008	-0							
	1233	1008	+0							
	1234	1008	-0	-0	0.3	6.2	10	0	0	
	1235	1008	+0	-0	0.3	6.2	10	0	0	
	1236	1008	-0	-0	0.3	6.2	10	0	0	
	1237	1008	+0	-0	0.3	6.1	10.1	0	0	
	1238	1008	-0	-0	0.3	6	10.5	0	0	
10/08/2016										DRY
	1155	1007	-0.1							
	1159	1007	-0.1							
	1201	1007	-0.1							
	1202	1007	-0.1	+0.38	0.2	2.3	17.7	0	0	
	1203	1007	-0.1	+0.38	0.2	2.3	17.6	0	0	
	1204	1007	-0.1	+0.38	0.2	2.3	17.7	0	0	
	1205	1007	-0.1	+0.38	0.2	2.2	17.7	0	0	
	1206	1007	-0.1	+0.38	0.2	2.2	17.8	0	0	
15/08/2016										DRY
	1225	1009	-0							
	1230	1009	+0							
	1232	1009	-0	+0.0	0.2	3.8	6.8	0	0	
	1233	1009	+0	+0.0	0.2	3.6	6.8	0	0	
	1234	1009	-0	+0.0	0.2	3.6	7.1	0	0	
	1235	1009	+0	+0.0	0.2	3.6	7.1	0	0	
	1236	1009	-0	+0.0	0.2	3.6	7	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2142		**T/D: 4.57 m BTOC**								
5/08/2016	[well cap fixed]									3.19
	954	993								
	955	993	-0.1							
	1000	993	-0.1							
	1001	993	-0.1	-0.09						
	1002	993	-0.1	-0.09	0	1.2	18.5	9	2	
	1003	993	-0.1	-0.09	0	1.2	18.6	9	2	
	1004	993	-0.1	-0.09	0	1.2	18.6	9	2	
	1005	993	-0.1	-0.09	0	1.2	18.6	9	2	
	1006	993	-0.1	-0.09	0	1.2	18.6	9	2	
8/08/2016										3.44
	1204	1002	-0.17							
	1207	1002	-0.17							
	1208	1002	-0.17	-0.17	0.1	0.5	20.4	0	0	
	1209	1002	-0.17	-0.17	0.1	0.5	20.5	0	0	
	1210	1002	-0.17	-0.17	0.1	0.5	20.5	0	0	
	1211	1002	-0.17	-0.17	0.1	0.5	20.5	0	0	
	1212	1002	-0.17	-0.17	0.1	0.5	20.5	0	0	
9/08/2016										3.6
	1241	1008	+0							
	1246	1008	-0.1							
	1248	1008	+0	-0.1	0.1	0.5	20.4	0	0	
	1249	1008	-0.1	-0.1	0.1	0.5	20.4	0	0	
	1250	1008	+0	-0.1	0.1	0.5	20.5	0	0	
	1251	1008	-0.1	-0.1	0.1	0.5	20.5	0	0	
	1252	1008	+0	-0.1	0.1	0.5	20.5	0	0	
10/08/2016										3.36
	1208	1007	+0							
	1213	1007	+0							
	1215	1007	+0	+0.31	0	0.4	20.5	0	0	
	1216	1007	+0	+0.31	0	0.4	20.6	0	0	
	1217	1007	+0	+0.31	0	0.4	20.6	0	0	
	1218	1007	+0	+0.31	0	0.4	20.6	0	0	
	1219	1007	+0	+0.31	0	0.4	20.6	0	0	
15/08/2016										3.39
	1238	1009	-0							
	1243	1009	-0							

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1245	1009	-0	+0.04	0.1	1.5	18.8	0	0	
	1246	1009	-0	+0.04	0.1	1.4	18.9	0	0	
	1247	1009	-0	+0.04	0.1	1.4	18.9	0	0	
	1248	1009	-0	+0.04	0.1	1.5	19	0	0	
	1249	1009	-0	+0.04	0.1	1.5	19	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2143		**T/D: 4.62 m BTOC**								
8/07/2016										DRY
	1043	993	+0.01							
	1047	993	+0.01							
	1049	993	+0.01	0	0	0.1	20.6	0	0	
	1050	993	+0.01	0	0	0.1	20.6	0	0	
	1051	993	+0.01	0	0	0.1	20.6	0	0	
	1052	993	+0.01	0	0	0.1	20.6	0	0	
	1053	993	+0.01	0	0	0.1	20.7	0	0	
	1054	993	+0.01	0	0	0.1	20.7	0	0	
14/07/2016										DRY
	1217	1001	0							
	1220	1001	-0.1							
	1222	1001	-0.1							
	1226	1001	-0.1	+0.1	0	0.2	20.5	0	0	
	1227	1001	-0.1	+0.1	0	0.2	20.5	0	0	
	1228	1001	-0.1	+0.1	0	0.2	20.5	0	0	
	1229	1001	-0.1	+0.1	0	0.2	20.5	0	0	
	1230	1001	-0.1	+0.1	0	0.2	20.5	0	0	
	1231	1001	-0.1	+0.1	0	0.2	20.5	0	0	
25/07/2016										DRY
	1434	1004	-0.2							
	1435	1004	-0.2	-0.4	0.1	0.2	20.5	0	0	
	1436	1004	-0.2	-0.4	0.1	0.2	20.5	0	0	
8/08/2016										DRY
	1256	1002	-0							
	1302	1002	-0.1							
	1305	1002	-0.1	-0.16	0.1	0.2	20.4	0	0	
	1306	1002	-0.1	-0.16	0.1	0.2	20.4	0	0	
	1307	1002	-0.1	-0.16	0.1	0.2	20.4	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1308	1002	-0.1	-0.16	0.1	0.2	20.4	0	0	
	1309	1002	-0.1	-0.16	0.1	0.2	20.4	0	0	
9/08/2016										DRY
	1255	1008	0							
	1300	1008	+0							
	1301	1008	+0	-0.01	0.1	0.3	20.7	0	0	
	1302	1008	+0	-0.01	0.1	0.3	20.8	0	0	
	1303	1008	+0	-0.01	0.1	0.3	20.8	0	0	
	1304	1008	+0	-0.01	0.1	0.3	20.8	0	0	
	1305	1008	+0	-0.01	0.1	0.3	20.8	0	0	
10/08/2016										DRY
	1222	1007	0							
	1224	1007	+0.1							
	1228	1007	+0.1	+0	0	0.4	20.7	0	0	
	1229	1007	+0.1	+0	0	0.4	20.7	0	0	
	1230	1007	+0.1	+0	0	0.4	20.7	0	0	
	1231	1007	+0.1	+0	0	0.3	20.8	0	0	
	1232	1007	+0.1	+0	0	0.3	20.8	0	0	
15/08/2016										DRY
	1251	1009	+0							
	1257	1009	+0	-0	0.2	0.3	20.3	0	0	
	1258	1009	+0	-0	0.2	0.3	20.3	0	0	
	1259	1009	+0	-0	0.2	0.3	20.4	0	0	
	1300	1009	+0	-0	0.2	0.3	20.4	0	0	
	1301	1009	+0	-0	0.2	0.3	20.4	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2145		**T/D: 4.66 m BTOC**								
8/07/2016	1102	993	-0.02							4.645
	1104	993	-0.02							
	1115	993	+0.38							
	1116	993	+0.38	+0.21	0	0.6	20.3	0	0	
	1117	993	+0.38	+0.21	0	0.6	20.2	0	0	
	1118	993	+0.38	+0.21	0	0.6	20.2	0	0	
	1119	993	+0.38	+0.21	0	0.6	20.1	0	0	
	1120	993	+0.38	+0.21	0	0.6	20.1	0	0	
	1121	993	+0.38	+0.21	0	0.6	20.1	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
11/07/2016										DRY
	1214	1015	0							
	1217	1015	-0							
	1218	1015	-0	+0.01	0.1	1.5	19.3	0	0	
	1219	1015	-0	+0.01	0.1	1.5	19.3	0	0	
	1220	1015	-0	+0.01	0.1	1.5	19.3	0	0	
	1221	1015	-0	+0.01	0.1	1.5	19.3	0	0	
	1222	1015	-0	+0.01	0.1	1.5	19.3	0	0	
14/07/2016										DRY
	1318	999	+0							
	1324	999	+0	-0.04	0	0.3	20.3	0	0	
	1325	999	+0	-0.04	0	0.3	20.3	20.3	20.3	
	1326	999	+0	-0.04	0	0.3	20.3	0	0	
	1327	999	+0	-0.04	0	0.3	20.3	0	0	
	1328	999	+0	-0.04	0	0.3	20.4	0	0	
	1329	999	+0	-0.04	0	0.3	20.4	0	0	
25/07/2016										DRY
	1441	1004	-0.1							
	1442	1004	-0.1	-0.05	0	0.1	20.6	0	0	
	1443	1004	-0.1	-0.05	0	0.1	20.6	0	0	
5/08/2016										4.64
	1011	993								
	1012	993	0							
	1017	993	0							
	1018	993	0	-0.07						
	1019	993	0	-0.07	0	0.5	20.1	9	2	
	1020	993	0	-0.07	0	0.5	20.1	9	2	
	1021	993	0	-0.07	0	0.5	20.1	9	2	
	1022	993	0	-0.07	0	0.5	20.2	8	2	
	1023	993	0	-0.07	0	0.5	20.2	8	2	
8/08/2016										DRY
	1310	1002	-2							
	1315	1002	-0.1							
	1316	1002	-0.1	-0.2						
	1317	1002	-0.1	-0.2	0.1	1.3	19.7	0	0	
	1318	1002	-0.1	-0.2	0.1	1.3	19.7	0	0	
	1319	1002	-0.1	-0.2	0.1	1.3	19.7	0	0	
	1320	1002	-0.1	-0.2	0.1	1.3	19.7	0	0	
	1321	1002	-0.1	-0.2	0.1	1.3	19.8	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
9/08/2016										4.65
	1309	1008	+0							
	1314	1008	-0							
	1315	1008	-0	-0.03	0.1	1.3	20.2	0	0	
	1316	1008	-0	-0.03	0.1	1.3	20.2	0	0	
	1317	1008	-0	-0.03	0.1	1.3	20.2	0	0	
	1318	1008	-0	-0.03	0.1	1.3	20.2	0	0	
	1319	1008	-0	-0.03	0.1	1.3	20.2	0	0	
10/08/2016										4.52
	1242	1007	+0							
	1247	1007	+0							
	1248	1007	+0	+0.02	0.1	1.5	19.7	0	0	
	1249	1007	+0	+0.02	0.1	1.5	19.7	0	0	
	1250	1007	+0	+0.02	0.1	1.5	19.7	0	0	
	1251	1007	+0	+0.02	0.1	1.5	19.7	0	0	
	1252	1007	+0	+0.02	0.1	1.5	19.7	0	0	
15/08/2016										DRY
	1303	1009	-0							
	1308	1009	+0							
	1309	1009	+0	+0.04	0.1	0.5	20.2	0	0	
	1310	1009	+0	+0.04	0.1	0.6	20.2	0	0	
	1311	1009	+0	+0.04	0.2	0.6	20.2	0	0	
	1312	1009	+0	+0.04	0.2	0.6	20.2	0	0	
	1313	1009	+0	+0.04	0.2	0.6	20.2	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2146		**T/D: 1.71 m BTOC**								
5/08/2016										DRY
	1028	993	0							
	1035	993	0	-0.09	0	1.9	18.4	9	2	
	1036	993	0	-0.09	0	1.9	18.4	9	2	
	1037	993	0	-0.09	0	1.9	18.4	9	2	
	1038	993	0	-0.09	0	1.9	18.4	9	2	
	1039	993	0	-0.09	0	1.9	18.4	9	2	
8/08/2016										DRY
	1320	1002	-0.22							
	1326	1002	-0.2							
	1327	1002	-0.2							

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1328	1002	-0.2	-0.22	0.1	0.3	20.3	0	0	
	1329	1002	-0.2	-0.22	0.1	0.3	20.4	0	0	
	1330	1002	-0.2	-0.22	0.1	0.3	20.4	0	0	
	1331	1002	-0.2	-0.22	0.1	0.3	20.4	0	0	
	1332	1002	-0.2	-0.22	0.1	0.3	20.4	0	0	
15/08/2016										DRY
	1315	1009	-0							
	1321	1009	-0							
	1322	1009	-1	-0.02	0.2	0.4	20.2	0	0	
	1323	1009	-2	-0.02	0.2	0.4	20.2	0	0	
	1324	1009	-3	-0.02	0.2	0.4	20.2	0	0	
	1325	1009	-4	-0.02	0.2	0.4	20.2	0	0	
	1326	1009	-5	-0.02	0.2	0.4	20.2	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2148		**not recorded**								
5/08/2016	[gas valve replaced]									0.95
	1103	993	-0							
	1108	993	-0							
	1109	993	-0	3.89						
	1110	993	-0	3.89	0	0.1	21.2	9	2	
	1111	993	-0	3.89	0	0.1	21.2	9	2	
	1112	993	-0	3.89	0	0.1	21.2	10	2	
	1113	993	-0	3.89	0	0.1	21.2	10	2	
	1114	993	-0	3.89	0	0.1	21.1	10	1	
8/08/2016										
	1347	1002								
	1351	1002	+0							
	1352	1002	+0							
	1353	1002	+0	+0	0.1	0.1	20.8	0	0	
	1354	1002	+0	+0	0.1	0.1	20.9	0	0	
	1355	1002	+0	+0	0.1	0.1	20.9	0	0	
	1356	1002	+0	+0	0.1	0.1	20.9	0	0	
	1357	1002	+0	+0	0.1	0.1	20.9	0	0	
9/08/2016										1.21

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1338	1008	-0							
	1342	1008	-0							
	1344	1008	-0	-0.04	0.1	0.1	20.8	0	0	
	1345	1008	-0	-0.04	0.1	0.1	20.8	0	0	
	1346	1008	-0	-0.04	0.1	0.1	20.8	0	0	
	1347	1008	-0	-0.04	0.1	0.1	20.8	0	0	
	1348	1008	-0	-0.04	0.1	0.1	20.8	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
10/08/ 2016										0.81
	1320	1007								
	1325	1007	-0							
	1326	1007	-0	-0.03	0.1	0.2	20.9	0	0	
	1327	1007	-0	-0.03	0.1	0.2	21	0	0	
	1328	1007	-0	-0.03	0.1	0.1	21	0	0	
	1329	1007	-0	-0.03	0.1	0.1	21	0	0	
	1330	1007	-0	-0.03	0.1	0.1	21	0	0	
15/08/ 2016										1.23
	1346	1009	-0.1							
	1349	1009	-0.1							
	1352	1009	-0.1							
	1353	1009	-0.1	+0	0.2	0.1	20.6	0	0	
	1354	1009	-0.1	+0	0.2	0.1	20.6	0	0	
	1355	1009	-0.1	+0	0.2	0.1	20.6	0	0	
	1356	1009	-0.1	+0	0.2	0.2	20.7	0	0	
	1357	1009	-0.1	+0	0.2	0.1	20.7	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2149		**T/D: 2.80 m BTOC**								
8/07/2016										1.255
	1127	993	0							
	1132	993	0							
	1133	993	0	-1.13						
	1134	993	0	-1.13	0	1	19.8	0	0	
	1135	993	0	-1.13	0.1	1	19.8	0	0	
	1136	993	0	-1.13	0.1	1	19.8	0	0	
	1137	993	0	-1.13	0.1	1	19.9	0	0	
	1138	993	0	-1.13	0.1	0.9	19.9	0	0	
11/07/2016										1.72
	1313	1014	-0.1							
	1317	1014	-0.1	-0.18	0.1	0.1	20.6	0	0	
	1318	1014	-0.1	-0.18	0.1	0.2	20.6	0	0	
	1319	1014	-0.1	-0.18	0.1	0.1	20.6	0	0	
	1320	1014	-0.1	-0.18	0.1	0.1	20.5	0	0	
	1321	1014	-0.1	-0.18	0.1	0.1	20.6	0	0	
	1322	1014	-0.1	-0.18	0.1	0.1	20.7	0	0	
14/07/2016										1.45
	1347	999	-0.0							
	1350	999	+0.1							
	1354	999	+0.1							
	1355	999	+0.1	+0.01	0	0.2	20.7	0	0	
	1356	999	+0.1	+0.01	0	0.1	20.8	0	0	
	1357	999	+0.1	+0.1	0	0.1	20.8	0	0	
	1358	999	+0.1	+0.1	0	0.1	20.9	0	0	
	1359	999	+0.1	+0.1	0	0.1	20.9	0	0	
	1400	999	+0.1	+0.1	0	0.1	20.9	0	0	
25/07/2016										1.36
	1457	1004	+0							
	1459	1004	+0	-0.06						
	1500	1004	+0	-0.06	0	0.1	20.7	0	0	
	1501	1004	+0	-0.06	0	0.1	20.7	0	0	
5/08/2016										1.24
	1116	993	0							
	1119	993	-0							
	1121	993	+0							
	1123	993	+0	+0.02	0	0.1	21	10	1	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1124	993	+0	+0.02	0	0.1	21	10	1	
	1125	993	+0	+0.02	0	0.1	21	9	1	
	1126	993	+0	+0.02	0	0.1	21	9	1	
	1127	993	+0	+0.02	0	0.1	21	9	1	
	1128	993	+0	+0.02	0	0.1	21	9	1	
8/08/2016										1.37
	1358	1002	-0.1							
	1403	1002	0							
	1405	1002	0	-0	0.1	0.1	20.9	0	0	
	1406	1002	0	-0	0.1	0.1	20.9	0	0	
	1407	1002	0	-0	0.1	0.1	21	0	0	
	1408	1002	0	-0	0.1	0.1	21	0	0	
	1409	1002	0	-0	0.1	0.1	21	0	0	
9/08/2016										1.47
	1350	1008	-0							
	1351	1008	-0.1							
	1356	1008	-0							
	1357	1008	-0	-0.09	0.1	0.1	20.8	0	0	
	1358	1008	-0	-0.09	0.1	0.1	20.8	0	0	
	1359	1008	-0	-0.09	0.1	0.1	20.8	0	0	
	1400	1008	-0	-0.09	0.1	0.1	20.9	0	0	
	1401	1008	-0	-0.09	0.1	0.1	20.9	0	0	
10/08/2016										1.06
	1334	1007								
	1339	1007	+0							
	1342	1007	-0							
	1343	1007	-0	-0.07	0.1	0.2	21	0	0	
	1344	1007	-0	-0.07	0.1	0.2	21	0	0	
	1345	1007	-0	-0.07	0.1	0.2	21.1	0	0	
	1346	1007	-0	-0.07	0.1	0.2	21.1	0	0	
	1347	1007	-0	-0.07	0.1	0.2	21.1	0	0	
15/08/2016										1.58
	1359	1009	-0.1							
	1404	1009	-0							
	1405	1009	-0	-0.01	0.2	0.1	20.8	0	0	
	1406	1009	-0	-0.01	0.2	0.1	20.8	0	0	
	1407	1009	-0	-0.01	0.2	0.1	20.8	0	0	
	1408	1009	-0	-0.01	0.2	0.1	20.8	0	0	
	1409	1009	-0	-0.01	0.2	0.1	20.9	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2150		**T/D: 3.30 m BTOC**								
8/07/2016										DRY
	1240	994	0							
	1241	994	0							
	1246	994	+0.01							
	1247	994	+0.01	0	0.1	0.3	20.4	0	0	
	1248	994	+0.01	0	0.1	8.4	10.5	0	0	
	1249	994	+0.01	0	0	8.4	9.2	0	0	
	1250	994	+0.01	0	0.1	8.5	9.2	0	0	
	1251	994	+0.01	0	0.1	8.5	9.1	0	0	
	1252	994	+0.01	0	0.1	8.5	9.1	0	0	
11/07/2016										DRY
	1331	1014	+0							
	1332	1014	+0							
	1334	1014	+0.1							
	1335	1014	+0.1	0	0.1	2.8	17.9	0	0	
	1336	1014	+0.1	0	0.1	2.8	17.8	0	0	
	1337	1014	+0.1	0	0.1	2.8	17.8	0	0	
	1338	1014	+0.1	0	0.1	2.9	17.8	0	0	
	1339	1014	+0.1	+0	0.1	2.9	17.8	0	0	
	1340	1014	+0.1	-0	0.1	2.9	17.7	0	0	
14/07/2016										DRY
	1404	999								
	1405	999	+0.1							
	1407	999	+0.1							
	1408	999	+0.2							
	1409	999	+0.2	+0.1	0	0.2	20.8	0	0	
	1410	999	+0.2	+0.1	0	2	18.5	0	0	
	1411	999	+0.2	+0.1	0	2	18.5	0	0	
	1412	999	+0.2	+0.1	0	2	18.5	0	0	
	1413	999	+0.2	+0.1	0	2	18.5	0	0	
	1414	999	+0.2	+0.1	0	2	18.5	0	0	
25/07/2016										DRY
	1503	1004	-0.2							
	1504	1004	-0.1							
	1506	1004	-0.1	0	0	1.2	19.5	0	0	
	1507	1004	-0.1	0	0	1.2	19.5	0	0	
5/08/2016										DRY

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1131	993								
	1132	993	0							
	1137	993	0							
	1138	993	0	-0.03	0	1.9	18.9	9	2	
	1139	993	0	-0.03	0	1.9	18.9	9	2	
	1140	993	0	-0.03	0	1.9	19	9	2	
	1141	993	0	-0.03	0	1.8	19.1	9	2	
	1142	993	0	-0.03	0	1.8	19.1	9	2	
8/08/2016										DRY
	1411	1002	-0							
	1416	1002	-0							
	1417	1002	-0	-0	0.1	2.8	17.7	0	0	
	1418	1002	-0	-0	0.1	2.8	17.7	0	0	
	1419	1002	-0	-0	0.1	2.9	17.7	0	0	
	1420	1002	-0	-0	0.1	2.9	17.7	0	0	
	1421	1002	-0	-0	0.1	2.9	17.6	0	0	
9/08/2016										DRY
	1403	1008	0							
	1408	1008	+0							
	1409	1008	+0	-0.12	0.1	2.2	18.6	0	0	
	1410	1008	+0	-0.12	0.1	2.2	18.6	0	0	
	1411	1008	+0	-0.12	0.1	2.2	18.6	0	0	
	1412	1008	+0	-0.12	0.1	2.3	18.6	0	0	
	1413	1008	+0	-0.12	0.1	2.3	18.6	0	0	
10/08/2016										DRY
	1350	1007								
	1351	1007	0							
	1356	1007	0							
	1358	1007	0	-0.08	0.1	4.5	13.5	0	0	
	1359	1007	0	-0.08	0.1	4.6	13.4	0	0	
	1400	1007	0	-0.08	0.1	4.6	13.4	0	0	
	1401	1007	0	-0.08	0.1	4.6	13.4	0	0	
	1402	1007	0	-0.08	0.1	4.6	13.3	0	0	
15/08/2016										DRY
	1411	1009	0							
	1417	1009	-0							
	1418	1009	-0	-0.02	0.2	2.6	17.7	0	0	
	1419	1009	-0	-0.02	0.2	2.6	17.7	0	0	
	1420	1009	-0	-0.02	0.2	2.6	17.7	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1421	1009	-0	-0.02	0.2	2.6	17.7	0	0	
	1422	1009	-0	-0.02	0.2	2.6	17.7	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2151		**T/D: 1.78 m BTOC**								
5/08/2016	[gas valve replaced]									DRY
	1217	993								
	1218	993	0							
	1223	993	0							
	1224	993	0	0.02	0	10	7.6	9	2	
	1225	993	0	0.02	0	10	7.6	10	2	
	1226	993	0	0.02	0	9.9	7.6	10	2	
	1227	993	0	0.02	0	9.9	7.6	10	2	
	1228	993	0	0.02	0	9.9	7.7	10	2	
8/08/2016										DRY
	1423	1002	-0							
	1428	1002	-0.1							
	1429	1002	-0.1	-0.01	0.1	5.5	15.3	0	0	
	1430	1002	-0.1	-0.01	0.1	5.5	15.4	0	0	
	1431	1002	-0.1	-0.01	0.1	5.5	15.4	0	0	
	1432	1002	-0.1	-0.01	0.1	5.5	15.4	0	0	
	1433	1002	-0.1	-0.01	0.1	5.4	15.6	0	0	
9/08/2016										DRY
	1418	1008	+0							
	1423	1008	+0							
	1425	1008	+0	-0.12	0.1	6.1	14.5	0	0	
	1426	1008	+0	-0.12	0.1	6	14.5	0	0	
	1427	1008	+0	-0.12	0.1	6.1	14.5	0	0	
	1428	1008	+0	-0.12	0.1	6.1	14.5	0	0	
	1429	1008	+0	-0.12	0.1	6.1	14.5	0	0	
10/08/2016										DRY
	1406	1007								
	1411	1007	+0.1							
	1412	1007	+0.1	-0	0.1	9.5	7.2	0	0	
	1413	1007	+0.1	-0	0.1	9.5	7.2	0	0	
	1414	1007	+0.1	-0	0.1	9.5	7.2	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1415	1007	+0.1	-0	0.1	9.4	7.3	0	0	
	1416	1007	+0.1	-0	0.1	9.3	7.4	0	0	
15/08/2016										DRY
	1425	1009	+0							
	1427	1009	+0.1							
	1430	1009	+0.1							
	1431	1009	+0.1	-0.01	0.2	6.5	13.5	0	0	
	1432	1009	+0.1	-0.01	0.2	6.5	13.5	0	0	
	1433	1009	+0.1	-0.01	0.2	6.5	13.5	0	0	
	1434	1009	+0.1	-0.01	0.2	6.5	13.5	0	0	
	1435	1009	+0.1	-0.01	0.1	6.5	13.5	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2152		**T/D: 2.10 m BTOC**								
8/07/2016										0.655
	1258	994								
	1301	994	+0							
	1306	994	+0							
	1307	994	+0	+5.94	0.1	4.9	17	0	0	
	1308	994	+0	+5.94	0.1	4.9	17	0	0	
	1309	994	+0	+5.94	0.1	4.9	17.1	0	0	
	1310	994	+0	+5.94	0.1	4.9	17.1	0	0	
	1311	994	+0	+5.94	0.1	4.9	17.1	0	0	
11/07/2016										0.97
	1344	1014								
	1345	1014	-11.7							
	1347	1014	-10.3							
	1349	1014	-6.7							
	1350	1014	+0.1							
	1351	1014	+0.1	+0	0.1	2	19.6	0	0	
	1352	1014	+0.1	+0	0.1	2.7	19.3	0	0	
	1353	1014	+0.1	+0	0.1	2.9	19.2	0	0	
	1354	1014	+0.1	+0	0.1	2.7	19.4	0	0	
	1355	1014	+0.1	+0	0.1	2.5	19.4	0	0	
14/07/2016										0.8
	1420	999	-7.7							
	1421	999	-7.1							

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1426	999	-4.8							
	1427	999	-4.8	-6.1	0	2.8	19.6	0	0	
	1428	999	-4.8	-6.1	0	3.4	19.3	0	0	
	1429	999	-4.8	-6.1	0	3.4	19.4	0	0	
	1430	999	-4.8	-6.1	0	3.5	19.3	0	0	
	1431	999	-4.8	-6.1	0	3.1	19.5	0	0	
25/07/2016										0.64
	1511	1004	+1.6							
	1512	1004	+1.1							
	1513	1004	+1.1	-0.08						
	1514	1004	+1.1	-0.08	0	3.9	19.2	0	0	
	1515	1004	+1.1	-0.08	0	3.9	19.2	0	0	
5/08/2016										0.535
	1146	993								
	1147	993	0							
	1152	993	0							
	1154	993	0	5.27	0	5.5	18.6	9	1	
	1155	993	0	5.27	0	5.5	18.6	9	1	
	1156	993	0	5.27	0	5.5	18.6	9	1	
	1157	993	0	5.27	0	5.1	18.9	9	1	
	1158	993	0	5.27	0	4.3	19.3	9	1	
8/08/2016										0.61
	1436	1002	-5.9							
	1437	1002	-5.3							
	1439	1002	-4.3							
	1441	1002	-3.5							
	1442	1002	-3.5	+0.02						
	1443	1002	-3.5	+0.02	0.1	4.6	19	0	0	
	1444	1002	-3.5	+0.02	0.1	4.6	19	0	0	
	1445	1002	-3.5	+0.02	0.1	4.6	19	0	0	
	1446	1002	-3.5	+0.02	0.1	4.5	19.1	0	0	
	1447	1002	-3.5	+0.02	0.1	4.4	19.2	0	0	
9/08/2016										0.67
	1442	1008								
	1443	1008	-6.3							
	1445	1008	-4.9							
	1446	1008	-4.4							
	1448	1008	-3.8							
	1449	1008	-3.8	+0.01	0.2	3.8	19	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1450	1008	-3.8	+0.01	0.2	3.1	19.9	0	0	
	1451	1008	-3.8	+0.01	0.2	3.1	19.9	0	0	
	1452	1008	-3.8	+0.01	0.2	3.1	19.9	0	0	
	1453	1008	-3.8	+0.01	0.2	2.8	20	0	0	
10/08/2016										0.52
	1419	1007								
	1420	1007	+9.3							
	1425	1007	+6.3							
	1426	1007	+6.3	-0.02	0.1	2.5	20.3	0	0	
	1427	1007	+6.3	-0.02	0.1	2.5	20.4	0	0	
	1428	1007	+6.3	-0.02	0.1	2.5	20.4	0	0	
	1429	1007	+6.3	-0.02	0.1	2.5	20.4	0	0	
	1430	1007	+6.3	-0.02	0.1	2.3	20.5	0	0	
15/08/2016										0.665
	1437	1009	-9.2							
	1438	1009	-6.2							
	1439	1009	-5.6							
	1440	1009	-5.1							
	1441	1009	-4.6							
	1442	1009	-4.1							
	1444	1009	-4.1	-0	0.1	4.1	19.6	0	0	
	1445	1009	-4.1	-0	0.1	4.3	19.6	0	0	
	1446	1009	-4.1	-0	0.1	4.6	19.5	0	0	
	1447	1009	-4.1	-0	0.1	4.6	19.6	0	0	
	1448	1009	-4.1	-0	0.1	4.7	19.6	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2153		**T/D: 1.93 m BTOC**								
8/07/2016										0.32
	1320	994								
	1325	994	+0							
	1326	994	+0	-0	0.1	2.3	19.7	0	0	
	1327	994	+0	-0	0.1	1.6	20	0	0	
	1328	994	+0	-0	0.1	1.2	20.2	0	0	
	1329	994	+0	-0	0.1	1.1	20.2	0	0	
	1330	994	+0	-0	0.1	1	20.3	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
11/07/2016										0.35
	1358	1014	-0							
	1403	1014	-0							
	1404	1014	-0	+0	0.1	1.5	20.2	0	0	
	1405	1014	-0	-0	0.1	1	20.4	0	0	
	1406	1014	-0	0	0.1	0.8	20.4	0	0	
	1407	1014	-0	0	0.1	0.8	20.5	0	0	
	1408	1014	-0	+0	0.1	0.7	20.5	0	0	
14/07/2016										0.34
	1434	999	+0.9							
	1435	999	+0							
	1440	999	+0	+0.1	0	4.4	19.3	0	0	
	1441	999	+0	+0.1	0	2.1	20.1	0	0	
	1442	999	+0	+0.1	0	1.3	20.3	0	0	
	1443	999	+0	+0.1	0	1.1	20.4	0	0	
	1444	999	+0	+0.1	0	1	20.4	0	0	
	1445	999	+0	+0.1	0	0.9	20.4	0	0	
25/07/2016										0.32
	1519	1004	+0							
	1521	1004	+0	-0.06						
	1522	1004	+0	-0.06	0	3.2	19.8	0	0	
	1523	1004	+0	-0.06	0	1.7	20.4	0	0	
5/08/2016										0.32
	1202	993								
	1203	993	0.6							
	1208	993	0.3							
	1210	993	0.3	0	0	8.3	18.2	9	2	
	1211	993	0.3	0	0	5.4	19.1	9	2	
	1212	993	0.3	0	0	4.2	19.4	9	2	
	1213	993	0.3	0	0	3	19.7	9	2	
	1214	993	0.3	0	0	2.3	19.9	9	2	
8/08/2016										0.34
	1448	1002	0							
	1453	1002	0							
	1455	1002	0	+0	0.1	3.2	20	0	0	
	1456	1002	0	+0	0.1	2.1	20.3	0	0	
	1457	1002	0	+0	0.1	1.7	20.4	0	0	
	1458	1002	0	+0	0.1	1.5	20.4	0	0	
	1459	1002	0	+0	0.1	1.4	20.4	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
9/08/2016										0.35
	1457	1008	+0.1							
	1501	1008	+0.1							
	1503	1008	+0.1	+0.05	0.1	2.3	20.3	0	0	
	1504	1008	+0.1	+0.05	0.1	1.4	20.7	0	0	
	1505	1008	+0.1	+0.05	0.1	1.1	20.8	0	0	
	1506	1008	+0.1	+0.05	0.1	1	20.8	0	0	
	1507	1008	+0.1	+0.05	0.1	0.9	20.9	0	0	
10/08/2016										0.26
	1434	1007								
	1435	1007	+1.2							
	1436	1007	+0.6							
	1440	1007	+0							
	1441	1007	+0	-0.01	0	4.6	19.9	0	0	
	1442	1007	+0	-0.01	0	3.4	20.2	0	0	
	1443	1007	+0	-0.01	0	2.2	20.6	0	0	
	1444	1007	+0	-0.01	0	1.8	20.8	0	0	
	1445	1007	+0	-0.01	0	1.6	20.8	0	0	
15/08/2016										0.35
	1452	1009	-0							
	1457	1009	+0.1							
	1459	1009	+0.1	-0	0.1	3	20	0	0	
	1500	1009	+0.1	-0	0.1	2	20.4	0	0	
	1501	1009	+0.1	-0	0.1	1.6	20.5	0	0	
	1502	1009	+0.1	-0	0.1	1.3	20.6	0	0	
	1503	1009	+0.1	-0	0.1	1.1	20.6	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2154		**T/D: 3.15 m BTOC**								
8/07/2016										1.33
	1335	994	0							
	1337	994	-0							
	1342	994	-0	+0	0	1	19.5	0	0	
	1343	994	-0	+0	0.1	0.8	19.2	0	0	
	1344	994	-0	+0	0.1	0.8	19.2	0	0	
	1345	994	-0	+0	0.1	0.8	19.2	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1346	994	-0	+0	0	0.8	19.3	0	0	
	1347	994	-0	+0	0	0.8	19.3	0	0	
11/07/2016										1.87
	1413	1014	+0							
	1418	1014	+0							
	1419	1014	+0	+0	0.1	0.1	20.7	0	0	
	1420	1014	+0	+0	0.1	0.1	20.7	0	0	
	1421	1014	+0	+0	0.1	0.1	20.7	0	0	
	1422	1014	+0	+0	0.1	0.1	20.7	0	0	
	1423	1014	+0	+0	0.1	0.1	20.7	0	0	
14/07/2016										1.86
	1449	999	-0.1							
	1451	999	-0.1	-0	0	0.8	20.3	0	0	
	1452	999	-0.1	-0	0	0.2	20.5	0	0	
	1453	999	-0.1	-0	0	0.2	20.5	0	0	
	1454	999	-0.1	-0	0	0.2	20.5	0	0	
	1455	999	-0.1	-0	0	0.2	20.5	0	0	
	1456	999	-0.1	-0	0	0.2	20.5	0	0	
25/07/2016										1.42
	1527	1004	-0							
	1529	1004	-0	-0.05	0	0.1	20.8	0	0	
	1530	1004	-0	-0.05	0	0.1	20.8	0	0	
5/08/2016										1.27
	1234	993								
	1235	993	0							
	1240	993	0.1							
	1241	993	0.1	-0.02	0	0.1	21	9	1	
	1242	993	0.1	-0.02	0	0.1	21	9	1	
	1243	993	0.1	-0.02	0	0.1	21.1	9	1	
	1244	993	0.1	-0.02	0	0.1	21.1	9	1	
	1245	993	0.1	-0.02	0	0.1	21.1	9	1	
8/08/2016										1.5
	1500	1002	-0.1							
	1506	1002	-0.1							
	1507	1002	-0.1	-0	0.1	0.1	20.5	0	0	
	1508	1002	-0.1	-0	0.1	0.1	20.5	0	0	
	1509	1002	-0.1	-0	0.1	0.1	20.5	0	0	
	1510	1002	-0.1	-0	0.1	0.1	20.5	0	0	
	1511	1002	-0.1	-0	0.1	0.1	20.5	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
9/08/2016										1.59
	1510	1008	-0							
	1515	1008	+0							
	1516	1008	-0	-0	0.1	0.2	21	0	0	
	1517	1008	+0	-0	0.1	0.2	21	0	0	
	1518	1008	-0	-0	0.1	0.2	21	0	0	
	1519	1008	+0	-0	0.1	0.2	21	0	0	
	1520	1008	-0	-0	0.1	0.2	21	0	0	
10/08/2016										1.04
	1449	1007	0							
	1451	1007	-3.6							
	1453	1007	-1.5							
	1454	1007	-0.5							
	1456	1007	-0.5	-0.02	0	0.3	21	0	0	
	1457	1007	-0.5	-0.02	0	0.3	21	0	0	
	1458	1007	-0.5	-0.02	0	0.3	21	0	0	
	1459	1007	-0.5	-0.02	0	0.3	21	0	0	
	1500	1007	-0.5	-0.02	0	0.3	21	0	0	
15/08/2016										1.62
	1505	1009	+0							
	1511	1009	+0.1							
	1512	1009	+0.1	-0.01	0.1	0.1	20.7	0	0	
	1513	1009	+0.1	-0.01	0.1	0.1	20.8	0	0	
	1514	1009	+0.1	-0.01	0.1	0.1	20.8	0	0	
	1515	1009	+0.1	-0.01	0.1	0.1	20.8	0	0	
	1516	1009	+0.1	-0.01	0.1	0.1	20.8	0	0	

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
Probe 2155		**T/D: 1.83 m BTOC**								
8/07/2016										1.62
	1351	994								
	1357	994	-4.8							
	1358	994	-4.8	+0	0	0.7	19.5	0	0	
	1359	994	-4.8	+0	0	0.7	19.5	0	0	
	1400	994	-4.8	+0	0	0.7	19.5	0	0	
	1401	994	-4.8	+0	0	0.7	19.6	0	0	
	1402	994	-4.8	+0	0	0.7	19.6	0	0	
11/07/2016										-

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1427	1014	0							
	1428	1014	0							
	1432	1014	0							
	1433	1014	0	-0.02	0.1	0.4	20.4	0	0	
	1438	1014	0	-0.02	0.1	0.4	20.5	0	0	
	1435	1014	0	-0.02	0.1	0.4	20.5	0	0	
	1436	1014	0	-0.02	0.1	0.4	20.5	0	0	
	1437	1014	0	-0.02	0.1	0.4	20.5	0	0	
14/07/2016										-
	1504	999	-0.2							
	1510	999	-0.2							
	1511	999	-0.2	-0.01	0	0.8	19.6	0	0	
	1512	999	-0.2	-0.01	0	0.8	19.7	0	0	
	1513	999	-0.2	-0.01	0	0.8	19.7	0	0	
	1514	999	-0.2	-0.01	0	0.8	19.7	0	0	
	1515	999	-0.2	-0.01	0	0.8	19.7	0	0	
25/07/2016										1.52
	1532	1004	-10.7							
	1533	1004	-9.8							
	1534	1004	-9.8	-0.06	0	0.6	20.6	0	0	
	1535	1004	-9.8	-0.06	0	0.6	20.6	0	0	
5/08/2016										1.3
	1247	993	-0							
	1248	993	-9							
	1251	993	-7.6							
	1253	993	-6.1							
	1255	993	-6.1	-0.28	0	1.2	20.6	9	1	
	1256	993	-6.1	-0.28	0	1.2	20.5	9	1	
	1257	993	-6.1	-0.28	0	1.2	20.6	9	1	
	1258	993	-6.1	-0.28	0	1.3	20.6	9	1	
	1259	993	-6.1	-0.28	0	1.2	20.6	9	1	
8/08/2016										1.43
	1514	1002	-8.2							
	1518	1002	-5							
	1519	1002	-5	-0.02	0.1	1.5	19.6	0	0	
	1520	1002	-5	-0.02	0.1	1.5	19.7	0	0	
	1521	1002	-5	-0.02	0.1	1.4	19.8	0	0	
	1522	1002	-5	-0.02	0.1	1.2	19.9	0	0	
	1523	1002	-5	-0.02	0.1	1.1	20	0	0	
9/08/2016										1.52

DATE	TIME	ATM PRESS (MB)	FLOW	REL PRESS	CH4 (%)	CO2 (%)	O2 (%)	CO (%)	H2S (%)	W/L (m BTOC)
	1525	1008	0							
	1526	1008	-5.4							
	1531	1008	-3.2							
	1532	1008	-3.2	+0.02	0.1	1.2	20.4	0	0	
	1533	1008	-3.2	+0.02	0.1	1.2	20.4	0	0	
	1534	1008	-3.2	+0.02	0.1	1.2	20.4	0	0	
	1535	1008	-3.2	+0.02	0.1	1.1	20.5	0	0	
	1536	1008	-3.2	+0.02	0.1	1	20.6	0	0	
10/08/2016										0.96
	1507	1007	-9.6							
	1503	1007	-8.3							
	1504	1007	-7.4							
	1505	1007	-6.1							
	1506	1007	-5.2							
	1507	1007	-4.3							
	1509	1007	-4.3	+0.01	0	1	20.7	0	0	
	1510	1007	-4.3	+0.01	0	1	20.7	0	0	
	1511	1007	-4.3	+0.01	0	1	20.7	0	0	
	1512	1007	-4.3	+0.01	0	1	20.8	0	0	
	1513	1007	-4.3	+0.01	0	0.9	20.8	0	0	
15/08/2016										1.43
	1520	1009	-12.7							
	1521	1009	-11.9							
	1522	1009	-11							
	1523	1009	-10.1							
	1524	1009	-9.1							
	1525	1009	-8.1							
	1526	1009	-8.1	-0.01	0.1	0.7	20.5	0	0	
	1527	1009	-8.1	-0.01	0.1	0.7	20.5	0	0	
	1528	1009	-8.1	-0.01	0.1	0.8	20.5	0	0	
	1529	1009	-8.1	-0.01	0.1	0.8	20.5	0	0	
	1530	1009	-8.1	-0.01	0.1	0.7	20.6	0	0	

3 Gas Monitoring in Leachate Manholes

The Project Team has undertaken gas monitoring at terminal leachate manhole MH3 (Drawing SKT-2330 in **Appendix A1)** and found peak gas concentrations of up to 4.2% methane (refer **Table E8**).

Table E8 Gas Concentration in MH3 Measured on 25 July 2016

Time (seconds)	CH_4 (%)	CO_2 (%)	O_2 (%)	CO (ppm)	H_2S (ppm)
60	4.2	2.4	19.9	0	0
120	3.8	2.3	19.6	0	0
180	3.5	2.3	19.6	0	0
240	3.2	2.1	19.7	0	0

Landfill gas monitoring has also been undertaken at leachate MH1C (refer **Table E9**) and only found traces of the landfill gas at this location. This suggests there are not significant amounts of Landfill gas migrating along the leachate lines that connect to this manhole.

Table E9 Gas Concentrations in MH1C Measured on 25 July 2016

Time (seconds)	CH_4 (%)	CO_2 (%)	O_2 (%)	CO (ppm)	H_2S (ppm)
0 (surface)	0.2	0.7	20.1	0	0
60 (1 m)	0.2	0.3	20.1	0	0

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Appendix E6

Landfill Gas Conceptual Model

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The Landfill is a municipal solid waste Landfill which accepted approximately 3.3 million tonnes of refuse from the late 1950s until September 2002. Waste was deposited on the western batter between 1979 and 1984 and is likely to be generating only low volumes of landfill gas concurrently. Overall, landfill gas peak production is likely to have occurred in 2001 and currently most of the landfill gas being an abstraction from the Landfill is occurring within gas abstraction wells along the northern side. It is from the northern side of the Landfill that the greatest pressure and LFG concentration gradients exist to generate lateral migration of landfill gas.

Surrounding the Landfill there is typically low permeability silty clay and clayey sands soils. The clayey sandy soils are more permeable than the silty clay soils and may act as a slightly more permeable gas/water migration pathway. Preliminary hydrogeological data suggests that there may be perched water-tables within elevated clayey sandy layers acting as a partial barrier to lateral gas migration as methane is only slightly soluble in the water. Currently, there is insufficient information on the seasonal variation of the water table in these perched layers to assess if prolonged periods of dry weather (or dewatering of these layers) would result in more permeable gas migration pathways.

High water tables encountered and potentially steeply dipping strata along the southern boundary of the Landfill will act as a barrier to lateral migration of landfill gas. As can be seen by the landfill gas conceptual site model (refer Drawing SKT-2331 in **Appendix A1**) the nearest receptors to the west of the Landfill are commercial buildings (Miro Street) which are significantly lower (approximately 10m) than the base of the refuse. The high regional groundwater table and the cut required as part of the Project will be effective barriers to prevent sub-surface gas migration to off-site receptors to the west of the Project area.

The scoria backfill surrounding the Landfill leachate drains may be acting as a preferential pathway for landfill gas. ESL has installed a vent on the leachate line near the western boundary of the Landfill. This passive Landfill vent should minimise the volume of landfill gas migrating off-site as it provides a pathway to be discharged vertically from the leachate lines.

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Appendix E7

Landfill Gas Migration Risk Assessment

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1 Introduction

A landfill gas migration risk assessment applicable to operation of the Project has been carried out. The assessment considers potential gas migration pathways and receptors and then determines landfill gas risk and appropriate protection measures that need to be implemented. The risk assessment process, results and recommendations are outlined below.

The purpose of undertaking the landfill gas risk assessment is to provide support for the selection of the remedial measures. As such, this landfill gas risk assessment gives sufficient detail to inform the selection of the appropriate remedial solution.

Where the conceptual site model shows that there are no linkages between the source and the receptor no further analysis has been undertaken to assess the risk to that receptor. This gas risk assessment has also been limited to the impact of the project will have on the gas pathways and, therefore, the risks posed by subsurface migration of landfill gas from other un-impacted parts of the landfill have not been assessed.

CIRIA C659/C665 establishes a methodology for undertaking a gas risk assessment, which involves a multi-step process which:

1. Establishes if the landfill gas monitoring data is reliable enough to undertake a risk assessment.
2. Identification of the source of the gas risks.
3. Development of a Conceptual Site Model.
4. Development of a risk model and qualitative assessment.
5. Selection of remedial measures.

1.1 Assessment of Data

This first step in any gas risk assessment is to assess the adequacy of the data to undertake a risk assessment. A review of the adequacy of the data has been undertaken in Chapter 4, sub-section 4.2.3. This assessment found that the number and frequency of the monitoring round was sufficient to meet the requirements in CIRIA C665. Unfortunately measurements of gas flow rate were not undertaken as part of the Council consent monitoring programme. It should be noted that in many of the monitoring rounds there was no evidence of landfill gas migration into the monitoring probes. Therefore, the gas flow rate has been assumed to be less than 0.05 l/hour.

To verify if this assumption was correct, the Project Team undertook nine rounds of landfill gas monitoring between 5 July and 15 August 2016. This monitoring data includes two landfill gas monitoring rounds undertaken when the barometric pressure was less than 1000mb and falling (worst case conditions). This monitoring programme confirmed the gas concentration data obtained by Council consent monitoring programme and confirmed that gas flow rates were less than 0.05 l/hr, even under rapidly falling barometric conditions. Therefore, the data is adequate to undertake a risk assessment.

1.2 Identification of Potential Receptors

A summary of potential sensitive receptors is presented in **Table 1 Appendix G**. Due to high groundwater levels along the southern boundary of the Landfill and the steep dipping of the strata to the south-east of the site, there is no linkage between the landfill and properties to the south of the Landfill.

Receptors along the eastern and north-eastern side of the Landfill are more than 250m from the impacted area of the Landfill and, therefore, given the low permeability strata outside the Landfill, low gas generation rates in this section of the Landfill and the distance from the Landfill there is considered to be no linkage between the Project area and these receptors.

There is evidence of possible gas migration pathways to the north of the Landfill as landfill gas has been detected in monitoring probes 2140 and 2141. However, methane concentrations within these monitoring wells have always been lower than the lower explosive limit of methane (5% methane). The potentially steep dipping of the strata in this area (perhaps up to 80°) is likely to limit any gas migration within the sandstone to relevantly short distances. Currently, there are no sensitive receptors on the northern side of the Landfill, however, this area is undergoing development and there may be receptors in this area in the future. These receptors are likely to be at least 300m away from the Landfill cut part of the Project area and given the low permeability of the strata surrounding the Landfill as well as the potentially steep dip of the strata, it is not expected that landfill gas will be able to migrate that far.

To the west of the site, the nearest sensitive receptors would be lighting and services (e.g. electrical) infrastructure within close proximity of the refuse which are proposed as part of the Project (refer Drawing SKT-2331 **Appendix A1**). Current gas monitoring has not detected the presence of any migrating landfill gas, which suggests that the permeability of the strata is too low to permit landfill gas migration or that the areas of landfill gas migration are too far away. However, due to the potential for dewatering of the shallow perched groundwater table as part of this Project it is possible, but unlikely, that landfill gas may be able to migrate this distance to these receptors.

1.3 Risk Assessment

1.3.1 Gas Screening Values

Gas screening values have been calculated for methane by multiplying the maximum methane concentration by the detection limit of the flow pod for the Landfill gas meter (0.05 l/hour)[1]. Where no methane has been detected in any of the monitoring rounds at a particular monitoring probe then the gas screening value has been assumed to be zero. This is a highly conservative estimate of the gas screening values and it almost certainly over-estimates the potential risks. Gas screening values have not been calculated for carbon dioxide for two reasons:

1. It is possible that the carbon dioxide readings recording at many of the monitoring wells are due to natural soil respiration processes.
2. Carbon dioxide is not flammable and therefore does not pose a risk to electrical infra-structure.

[1] Note this approach is consistent with the recommendations of CIRIA C665.

The Gas Screening values are presented in **Table E10** below.

Table E10 Gas Screening Values

Monitoring probe	Maximum methane	Maximum flow rate	Gas Screening value
2140	0.6	<0.05	<0.0003
2141	3.6	<0.05	0.0018
2142	0.1	<0.05	<0.000 05
2143	0.2	<0.05	<0.000 1
2144	0	<0.05	0
2145	0	<0.05	0
2146	0	<0.05	0
2147	0	<0.05	0
2148	0.1	<0.05	<0.000 05
2149	0	<0.05	0
2150	0	<0.05	0
2151	0	<0.05	0
2152	0	<0.05	0
2153	0	<0.05	0
2154	0	<0.05	0
2155	0	<0.05	0

As can be seen for **Table E10**, the gas screening values for all monitoring wells along the western and southern side of the landfill are less than 0.07 l/hr. Using the modified Wilson and Card classification scheme a gas screening value of less than 0.07 l/hr is considered very low risk (gas characteristic situation 1). However, since carbon dioxide readings do occasionally exceed 5% C665 recommends that the gas characteristic situation is increased to level 2.

1.3.2 Risk Screening Process

A risk screening assessment has been undertaken using the risk assessment framework described in AS/NZS/ISO 31000:2009 and HB2003:2012. The conceptual gas migration site model (refer Drawing SKT-2331 in **Appendix A1**) has indicated that there is a possible migration pathway to the lighting and underground services infrastructure within the Project area.

Current landfill gas monitoring indicates there are no active pathways within the upper 3m of soil. However, it is possible that dewatering of the perched groundwater table might result in a gas migration pathway becoming viable. The likelihood of this pathway within the Project area is considered to be low. In addition, the consequences of a build-up of methane (fire and damage to lighting infra-structure) would be considered to be minor (easily repairable damage to infrastructure) to mild (significant damage to services). Therefore, using the risk assessment framework in AS/NZS/ISO 31000:2009 the risk of such an occurrence is very low to low.

1.4 Selection of Gas Protection Measures

The gas characteristic situation calculated above can be used to define the general scope of the gas protection measures required using the methodology outlined in **Table E11**.

Table E11 Typical Scope of Gas Protection Measures (from CIRIA C665)

Characteristic Situation	Office/Commercial/Industrial Development
	Number of levels of Protection
1	None
2	1 to 2
3	1 to 2
4	2 to 3
5	3 to 4
6	4 to 5

Based on a calculated gas characteristic situation of 2, between one and two levels of gas protection are required. It is common practice to adopt the concept of multiple gas protection measures, since no one protection measure is immune to failure (Wilson, Card and Haines, 2009). In addition, dewatering of the perched groundwater layers along the potential pathway could increase the risk of gas migration, therefore, two levels of protection are recommended.

Control of gas migration is typically accomplished by breaking the migration pathway between the source (the Landfill) and the receptor (in this case the sub-surface infra-structure). Of the available options to control landfill gas migration, the most suitable for this project have been assessed to be installing a low permeability barrier (e.g. engineering clay) and a passive venting trench (i.e. gas interception trench) behind the barrier to increase the redundancy within the system (refer Drawing SKT2342 **Appendix A1**).