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Report No 4756/R01/02

WITHYHEDGE LANDFILL SITE

LEACHATE MANAGEMENT PLAN

Prepared for

Resources Management UK Ltd



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LEACHATE MANAGEMENT PLAN

July 2020

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WITHYHEDGE LANDFILL SITE
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DRAWINGS

1111/TP/04:02	Topographic Survey January 2020 (East)
1111/TP/01:01	Leachate Monitoring Locations
4756/001/01	Monitoring Locations

APPENDICES

Appendix A Previous LMP submissions

Leachate management Plan, Phase 1, Ref 07514290132.501 (Golders, May 2008)
Leachate management Plan, Phase 2, Ref 06529234.508 (Golders, June 2007)
Leachate management system review, Ref 11514290005.501/A.0 (Golders, Sep 2011)

Appendix B Withyhedge Water Balance

Appendix C Recirculation Documentation & Gas Management Plan (2014) / Addendum (2016) & EXEA Associates Ltd, January 2018 (WITHYHEDGE LANDFILL SITE - Landfill Gas Risk Assessment Report 1) Ref EXEA/Permit EPR/GP3630HTV005

1. INTRODUCTION

1.1 Background

An updated Leachate Management Plan (LMP) is required as per the Permit Requirement (MP3330WP) at Table S1.4a (4) which states:

“Prior to any recirculation of leachate within the boundary of the landfill, the operator shall submit to the Environment Agency (for approval) an updated leachate management plan which shall include:

- *The volume of leachate to be recirculated including an assessment of the potential impact of such activity to groundwaters, surface waters and generation of odours;*
- *Evidence that the proposed recirculation system is designed to minimise air ingress into the landfill;*
- *A review of the pre-treatment requirements of leachate, prior to disposal and/or recirculation (unless already undertaken and approved as part of the Improvement Programme;) and*
- *The Landfill gas extraction system has been installed to collect and treat any gas generated as a result of recirculation”*

Additionally, it was requested by Natural Resources Wales (NRW) at a meeting in October 2019 that the following issues were included within the LMP update (or associated documents):

- Monitoring frequency discussion (with an updated frequency suggested)
- Updated monitoring plan (drawing 4756/1/001)
- As built details of current gas and leachate systems – automated details
- Appraisal of gas field function – (Appendix C)
- Detail of training, alarm notifications etc.

1.2 Structure of the report

The LMP is to set out a clear guide for the on-going operation of the leachate infrastructure at the landfill. The plan is to include contingency plans in the event that any infrastructure or the control of leachate levels is lost. Associated Gas details are provided in Appendix C.

The report is designed to address the holistic site’s leachate management requirements, the layout follows the previous LMP’s as these documents have already been approved by NRW under earlier submissions. This LMP builds upon previous reports dated 2008¹ (for Phase1) and 2007 for Phase 2² and includes information contained within a 2011 system review³. Guidance on Leachate management is detailed in “How to comply with your environmental permit Additional guidance for: Landfill (EPR 5.02)” dated October 2014 - (<https://naturalresources.wales/media/2111/how-to-comply-with-your-environmental-permit-additional-guidance-for-landfill-epr-502.pdf>).

¹ Leachate management Plan, Phase 1, Ref 07514290132.501 (Golders, May 2008)

² Leachate management Plan, Phase 2, Ref 06529234.508 (Golders, June 2007)

³ Leachate management system review, Ref 11514290005.501/A.0 (Golders, Sep 2011)

The report includes the following:

1. Desk based review of previous (2007, 2008 and 2011) LMPs and updates;
2. Desk based review of existing extraction system;
3. Description of leachate recirculation infrastructure and operating capacity
4. Summarising the landfill in terms of:
 - landfill design and technical precautions / management controls (including summarising relevant CQA information where available);
 - waste types, quantities, filling periods; and
 - Leachate composition and volume within each zone of the site.
5. Summary of the migration pathway *i.e.* the geology and hydrogeology of the unsaturated zone (if there is unsaturated zone);
6. Summarising previous rationalisation and derivation of extraction volumes;
7. Propose changes through detailed water balance and technical justification;
8. Describe maintenance and inspections;
9. Describe remediation – wells and pumping infrastructure;
10. Recommendations as to changes to the monitoring programme / frequencies;
11. Review the site's Action Plan and reporting protocol.

2. SITE SUMMARY

2.1 Site Setting

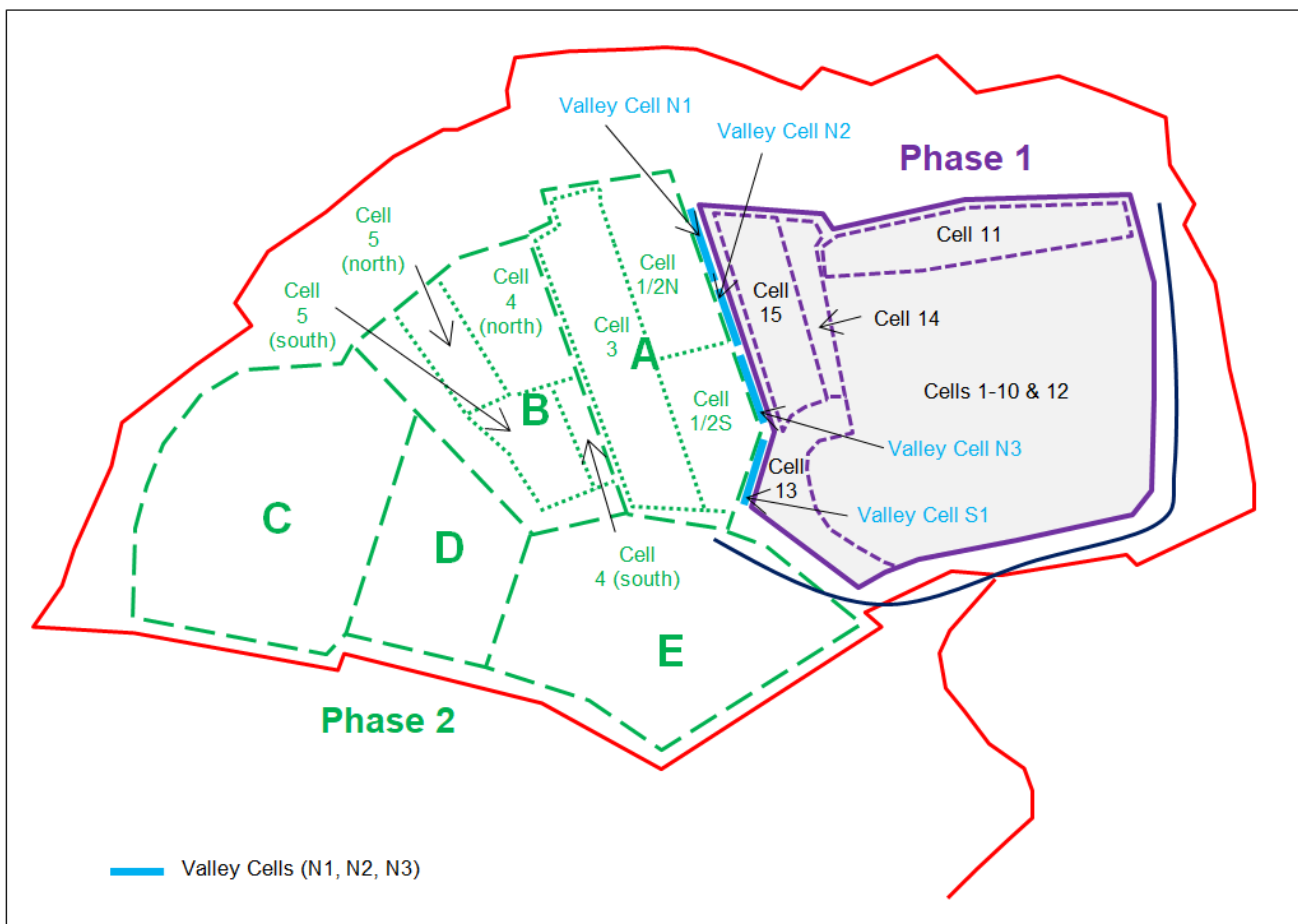
The Site is bound to the north and west by Rudbaxton Water and to the south and east by agricultural land. The elevation of the site is at approximately 70 mAOD in the east and approximately 50 mAOD in the west. Rudbaxton Water is at an elevation of approximately 30 to 35 mAOD.

2.2 Site Phasing & Historical Development

The site boundary encompasses an area which is divided into Phase 1 (approx. 18.5 ha) and Phase 2 (approx. 34.1 ha) of which the currently operational and developed area is approximately 14.7 ha.

A simplified Phase / Cell layout depiction is provided as Figure 1 (taken from the 2019 HRAR⁴ and updated accordingly with current development).

Figure 1 Site Phase & Cell Layout



Red line = Permit Boundary.

Purple line; (Phase 1), green line; (Phase 2) dark blue line, groundwater cut-off barrier (taken from ESID 4, 2003) - All boundaries are indicative and are for illustrative purposes only. Cell 4 and 5 south – under construction

⁴ TerraConsult Ltd (September 2019). Hydrogeological Risk Assessment Review (Ref 3933/R/001/02)

Before development of the landfill, the Site had been in use for agricultural purposes. According to the 2007 HRAR⁵, *“the Site was run by Pembrokeshire County Council under a Resolution and accepted waste from 1985. Planning consent and a Waste Management Licence was awarded to RML in January 1996 (WML SWW/163/L) under the Waste Management Licensing Regulations (1994)”*.

“The Site operated as a non-hazardous waste landfill, and has not accepted hazardous waste since 16 July 2004. Phase 1 accepted its final waste in December 2006. A PPC Permit has been granted for landfilling in the area to the west of the existing Site (Phase 2). Phase 1 has a total of fifteen cells. Much of the Site operated on a dilute and disperse basis (Cell 1-10 and 12), however, four of the landfill phases (Cell 11, 13, 14 and 15) have been engineered with artificially established mineral barriers. The exact layout of Cells 1 to 10 and 12 is unknown.”

It has been previously reported that the site occupies the void space left by the removal of superficial deposits and mudstone bedrock as each landfill cell is constructed. Clays are preserved for engineered cell lining systems and other material is retained for daily cover, inert fill and capping soils⁶.

⁵ Golder Associates Ltd (November 2007). Hydrogeological Risk Assessment, Withyhedge Landfill Phase 1 (report reference 07514290132.500)

⁶ Golder Associates Ltd (June 2005). Section A Environmental Setting and Installation Design (ESID) Withyhedge Landfill Phase 2 (report reference 04529421.501/A.0)

3. ENGINEERING

Phase 1 is predominantly a dilute and disperse area; Phase 2 is designed on the principle of engineered containment (Figure 1). A summary of engineering aspects taken from previous reports are provided below and summarised in Table 1.

3.1 Phase 1

Phase 1 (Cell 11)

Cell 11 is a rectangular shape cell located along the northern boundary of Phase 1. "The basal liner comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s. A 5m high clay bund was constructed along the northern edge⁷ (referenced in Golders 2007) and confirmed by Golders in 2011"⁸.

Table 1 Engineering Summary – Base & Cap

Phase	Area	Cells	Lining System	Capping System	Base datum (mAOD)
1	-	1 to 9	Unlined	Composite: 0.001m LLDPE 1m Engineered Clay	-
		10	Unlined	0.001m LLDPE	-
		11	1m Engineered Clay	Composite: 0.001m LLDPE 1m Engineered Clay	-
		12	Unlined	0.001m LLDPE	-
		13	1m Engineered Clay	0.001m LLDPE	46.5
		14	1m Engineered Clay	0.001m LLDPE	45.0
		15	Composite Liner: 0.002m HDPE, 1m Engineered Clay	0.001m LLDPE	45.5
2	A	1/2 North	Composite Liner: 0.002m HDPE, 1m Engineered Clay	0.001m LLDPE	44.7
		1/2 South	Composite Liner: 0.002m HDPE, Geo-synthetic clay liner 0.5m Engineered Clay	0.001m LLDPE	46.0
		3	Composite Liner: 0.002m HDPE, Geo-synthetic clay liner 0.5m Engineered Clay	0.001m LLDPE	42.0
	B	4 North 5 North	Composite Liner: 0.002m HDPE, Geo-synthetic clay liner 0.5m Engineered Clay	tbc	39.0
		4 South 5 South	Under construction – As per 4&5 North	tbc	tbc
	C, D, E	Pre Operational	-	-	-
	Valley	Cell N1, N2,N3 Cell S1	Composite Liner: 0.002m HDPE, Geo-synthetic clay liner 0.5m Engineered Clay	0.001m LLDPE	N1 (45.1) N2 (46.9) N3 (47.1) S1 (48.5)

Information reported in¹⁵ and various annual monitoring reviews, Phase 2, area B – Cell 4 (north) data from 2018 CQA⁹

⁷ CL Associates (1995). Withyhedge Landfill Earthworks Construction of Base Seal and Peripheral Bund for Cell 11, 6770/13, September 1995 – Referenced in Golders 2007

⁸ Golder Associates Ltd (2011). Withyhedge Leachate Management System Review, Report 11514290005.501/B.1

⁹ CQA International Ltd (July 2018) Ref 30323-02

Phase 1 (Cell 13)

Cell 13 is a crescent shape located in the southwestern corner of Phase 1. "It has a basal area of approximately 11,500 m². The basal lining system comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s (AIG Consultants Ltd., 2001¹⁰ - reference in Golders 2007). The base of Cell 13 is 46.5 m AOD, increasing to 50 m AOD at the outer edges"⁸.

Phase 1 (Cell 14)

"Cell 14 is a broad rectangular shape located in the north-western area of Phase 1. It has a basal area of approximately 6000 m². The basal liner comprises 1 m thick engineered clay with a permeability of not more than 1×10^{-9} m/s (AIG Consultants Ltd., 2002¹¹ - referenced in Golders 2007). Cell 14 basal elevations range from 48.7 m AOD to 45 m AOD at the collection sump".

Phase 1 (Cell 15)

"Cell 15 is approximately rectangular and has an area of approximately 20,000 m². It is located in the north-western corner of Phase 1. The basal liner comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s. The engineered clay is overlain by a 2 mm thick smooth HDPE geomembrane, which is overlain by a protective geotextile (AIG Consultants Ltd., 2004¹² - referenced in Golders 2007). Based on the as built drawings for Cell 15, basal elevations range from 45.45 to 48.3 m AOD"⁸.

3.2 Phase 2

Phase 2 – Area A (Cell 1/2N)

According to the 2008 Annual Monitoring Review¹³, landfilling commenced in December 2006, the Cell 1/2N area was constructed with a 1m clay liner overlain with a 2mm HDPE and protective geotextile. Further details are contained in the Golder Associates 2006b CQA validation report¹⁴ (not reviewed in this document). "Basal elevations range from approximately 46.8 to 44.7 m AOD at the collection sump"⁸.

Phase 2 – Area A (Cell 1/2S)

According to previous summary tables¹⁵ the base liner system is comprised of 0.5m engineered clay, 0.002m HDPE and geosynthetic clay liner. A CQA report¹⁶ details that "the lining system comprises a composite liner over the base and internal faces of the perimeter bunds. The lining system comprises a 0.5 m thick layer of engineered clay with a maximum permeability of 1.0×10^{-8} m/s overlain by a Geosynthetic Clay Liner (GCL) with a maximum permeability of 1.0×10^{-11} m/s and a 2 mm thick textured high density polyethylene (HDPE) geomembrane."

¹⁰ AIG Consultants Limited (December 2001). Withyhedge Landfill Site Cell 13 CQA Certification Report, UK01/2139/6

¹¹ AIG Consultants Limited (October 2002). Withyhedge Landfill Site Cell 14 CQA Certification Report, UK02/2139/4

¹² AIG Consultants Limited (October 2004). Withyhedge Landfill Site Cell 15 Construction Quality Assurance Certification Report, UK04/2139/3

¹³ Golder Associates UK Limited (July 2008). Withyhedge Landfill Site Phase 2 Environmental Monitoring Review

¹⁴ Golder Associates UK Limited (2006b). Withyhedge Landfill Site Phase 2, Construction of Cell 1 and 2 North CQA Report, 06529233.505

¹⁵ SUEZ (Sept 2010-Aug 2011). Withyhedge Landfill Site Environmental Monitoring Review and Risk Assessment

¹⁶ Golder Associates UK Limited (Jan 2008). Withyhedge Landfill Phase 2, Construction of Cells 1 and 2 South. CQA Report 07514290178.503

“The engineered clay was overlain by a low permeability Geosynthetic Clay Liner (GCL) placed on the base and internal perimeter side slopes and anchored at the top of the side slopes.” All testing criteria and results are included within the Report 07514290178.503”¹⁶.

Clay liner formation levels according to drawing 503/3 fall from 47.6 mAOD in the south of the cell to circa 46 mAOD in the north.

Phase 2 – Area A (Cell 3)

Golders 2011⁸ report that “cell 3 was divided in to a north and south area, both comprise of a 0.5 m thick layer of engineered clay (maximum permeability of 1.0×10^{-8} m/s) overlain by GCL with a maximum permeability of 1.0×10^{-11} m/s and 2 mm HDPE geomembrane and protective geotextile. Base elevations for the south range from 46 to 43 mAOD and 44.5 to 42 mAOD for the north”.

Valley Cell N1 & N2

Since the submission of the 2012 HRAR by SUEZ, the Valley area has been designed; permitted and infilled, details are contained in Report 2185-R3-1 (2015)¹⁷. The application and associated approval joined Phase 1 to Phase 2.

After formation preparation, the *in-situ* clay was reworked and placed in 250 mm layers with a shear strength of greater than 50 kN/m². Surveying demonstrated a thickness equal to or greater than 500 mm, a Geosynthetic Liner (GCL) was placed over the engineered clay liner. The GCL was placed in rolls simultaneously with the overlying FML to ensure that the GCL was not prematurely hydrated by rainfall. Top of formation according to CQA drawing 2185/7/001 ranges between 46.3 mAOD (southern end) and 43.9 mAOD, (northern end) clay thickness is typically 600 – 660 mm. Top of clay liner is typically 46.9 mAOD in the south and 45.1 mAOD in the north (drawing 2185/7/004).

The FML comprised of a 2 mm High Density Polyethylene, air pressure seam testing was carried out on all welds prior to the placement of the protective geotextile. All testing criteria and results are included within the TerraConsult Report 2185-R3-1¹⁷.

Valley Cell N3 & S1

Top of formation according to CQA drawing 2185/8/001 for N3 ranges between 47.6 mAOD (southern end) and 46.2mAOD, (northern end) clay thickness is typically 600 – 800 mm. Essentially, N3 forms part of the N2 and N1 cells, draining leachate northwards. Top of clay liner is typically 48.2mAOD in the south and 47.1mAOD in the north (drawing 2185/8/004).

Cell S1 ranges from 48.3 mAOD in the north and 47.3 mAOD at the southern end (drawing 2185/8/001 with a clay thickness of typically 700 mm. Top of clay liner is typically 49.1 mAOD in the north and 48.5 mAOD in the south (drawing 2185/8/004).

¹⁷ TerraConsult (November 2008). Withyhedge Landfill Site Valley Cells N1 & N2 Construction Works – Validation Report Ref 2185-R3-1

The FML comprised of a 2mm High Density Polyethylene, air pressure seam testing was carried out on all welds prior to the placement of the protective geotextile. All testing criteria and results are included within the Report 2185-R4-1 (2016)¹⁸.

Phase 2 – Area B (Cell 4 North)

The cell is located to the west of Cells 3N and 3S, and the eastern edge ties into Cells 3N and 3S. Average Clay permeability ranged is stated at 2.2×10^{-10} m/s, top of formation ranges between 41 mAOD in the south eastern-corner reducing to 39 mAOD in the north-western corner. Clay thickness is typically 600-700mm⁹.

Phase 2 – Area B (Cell 5 North)

The cell is the latest at site to be infilled with waste, the eastern edge ties into Cell 4N. The design criteria for the permeability of the clay is no greater than 1×10^{-9} m/s at (assumed a typo, which should read than 1×10^{-9} m/s) and thickness of at least 500mm¹⁹. This is overlain by a geosynthetic clay liner and 2mm thick HDPE flexible membrane liner. The top of formation ranges between 39mAOD at the south, reducing to ~37.5 mAOD in the north. Lining works were carried out between July and October 2019. Clay source permeabilities ranged between 2.9×10^{-10} m/s and 6.5×10^{-10} m/s, engineered thicknesses exceed 0.5m with base liner permeabilities of 2.2×10^{-10} m/s; 1.8×10^{-10} m/s, 3.5×10^{-10} m/s 1.7×10^{-10} m/s, 8.7×10^{-10} m/s; 1.4×10^{-10} m/s, 2.1×10^{-10} m/s, 8.8×10^{-11} m/s, 1.4×10^{-10} m/s and 1.4×10^{-10} m/s.

Phase 2 – Area B (Cells 4 South and 5 South)

Cells 4S and 5S will be one cell with no inter-cell bund. They are both currently under construction, in preparation for the next phase of filling once cell 5N has been filled and completed. They will be constructed with the same specifications for the liner system as cells 4 North and 5 North. Clay source material is the same as utilised for Cell 5, liner test permeabilities are recorded at 5.6×10^{-10} m/s and 3.5×10^{-10} m/s. A design fall of 1:50 is proposed to a low point in the north west corner of Cell 5S.

3.3 Capping Status and Relevant Updates

The Golders 2011 leachate management review indicated that:

The majority of Phase 1 is permanently capped with overlapped geomembrane and clay composite onto which subsoil and topsoil restoration materials have been placed. An area of Cells 1-10 and 12 (13,500m²) where a skip park is currently located, cell 13 and cell 15 are temporary capped. Permanent capping will take place during 2012.

In Phase 2, a temporary cap was installed in March 2012 on cells 1 and 2 north, the remaining cells remain open waste.

As part of the Valley Cells capping and restoration²⁰ (as part of permit Table S3.1, Improvement Program Requirements, IC19), the associated report details the completion of the valley cell area. This included regrading, reparation of a 300mm cap subgrade regulating

¹⁸ TerraConsult (March 2016). Withyhedge Landfill Site Valley Cells N3 & S1 Construction Works – Validation Report Ref 2185-R4-1

¹⁹ TerraConsult (October 2019). Withyhedge Landfill Site Valley Cell 5N Construction Works – Validation Report Ref 4603-R3-1

²⁰ TerraConsult (November 2019). Withyhedge Landfill Site Valley Cells VCS1 – VCS3 Capping and Restoration Validation Report Ref 4580-R1-1

layer using suitable on-site materials where deemed necessary, placement of a 1mm thick linear low density polyethylene (LLDPE) geomembrane liner, protective geotextile layer and placement of a 600mm thick restoration soils layer above the protective geotextile across the full capping area. The work was carried out between July and October 2017.

According to the 2018 Flux Box survey, six zones were identified as requiring Annual FID Surveying: Zones 1 and 3 comprising of permanent welded geomembrane capping, Zone 2 comprising of permanent lapped geomembrane capping and Zones 4, 5 and 6 comprising of temporary capping²¹. Part of Zone 6 was subsequently identified as being operational with no temporary capping.

The drawings indicate that

- Zone 1 is the western half of Phase 1 (permanently capped with geomembrane)
- Zone 2 is eastern half of Phase 1 (permanently capped with geomembrane)
- Zone 3 comprises the majority of Cell 3 (permanently capped with geomembrane)
- Zone 4 comprises Cell 1/2 N, Cell 1/2 S and Cell 15 (partially permanently capped with geomembrane)
- Zone 4, 5 and 6 remainder of Area A (temporary capping)

A recent appraisal of information indicates that:

- Phase 1
 - Permanent Capping in place
- Valley Cells – Approximately 50% permanent capping, 50% temporary capping
- Phase 2
 - 1/2 North – Approximately 50% permanent capping, 50% temporary capping
 - 1/2 South – Approximately 30% permanent capping, 70% temporary capping
 - 3 North – Approximately 50% permanent capping, 50% temporary capping
 - 3 South – Approximately 30% permanent capping, 70% temporary capping
 - 4 North – Cover only
 - 5 North – Cover Only

The remaining areas of 3 North, majority of 4 North and 50% of 5 North are scheduled for permanent capping in 2020, the CQA plan is to be issued to NRW in July / August.

²¹ Annual FID Survey Report. Withyhedge Landfill Site, 2018. Enitial

4. WATER BALANCE

4.1 Introduction

The purpose of this LMP and water balance is to amalgamate the two previously different phases of Withyhedge Landfill, Phase A and Phase B and also include the valley infill cells (N1-N3 and S1). Individual leachate management plans have been compiled for each phase of the landfill, by Golder Associates (Golders), in 2007 for Phase B and in 2008 for Phase A. The rational and assessment within this update is consistent with the previously submitted and accepted documents. Previous submissions are included in Appendix A.

As with the previous water balance assessments, this water balance will be used to calculate the leachate generation, the leachate storage capacity of the landfill, and therefore the volume of leachate needed to be pumped from the landfill to ensure that the leachate levels remain below their respective compliance levels.

The water balance calculation is based on the standard water balance equation, where the rate of inflow of water, minus the rate of outflow of water, equals the rate of change of the quantity of water within the landfill.

4.2 Effective Rainfall

The effective rainfall values for operational cells, temporarily capped cells and permanently capped cells will be the same as those used in the water balance in the 2011 leachate management review. The effective rainfall was calculated using the site specific rainfall data from 2007-2011, and the evapotranspiration data from MAFF (1976).

Between 2007 and 2011 rainfall ranged between 937 and 1538mm/y (average of 1142mm/y). Met Office rainfall data for Aberporth for 2018 and 2019 was 931 and 1004mm/y respectively hence previously calculated figures for effective rainfall are considered to remain valid.

The effective rainfall values previously calculated are ~600mm per year to open waste, 150mm per year for temporarily capped cells and 30mm per year for permanently capped cells. The values are based on a calculation on the amount of rainfall which will infiltrate the capping soil, after runoff and evapotranspiration losses have been accounted for.

The leachate management review undertaken by Golders in 2011 performed a water balance using effective rainfall from a 3 month period between November 2009 and January 2010. This was to determine the volume of leachate would be produced during a “wet scenario” an “average scenario” which could then be judged against further permanent capping undertaking.

4.3 Surface Water Run-Off

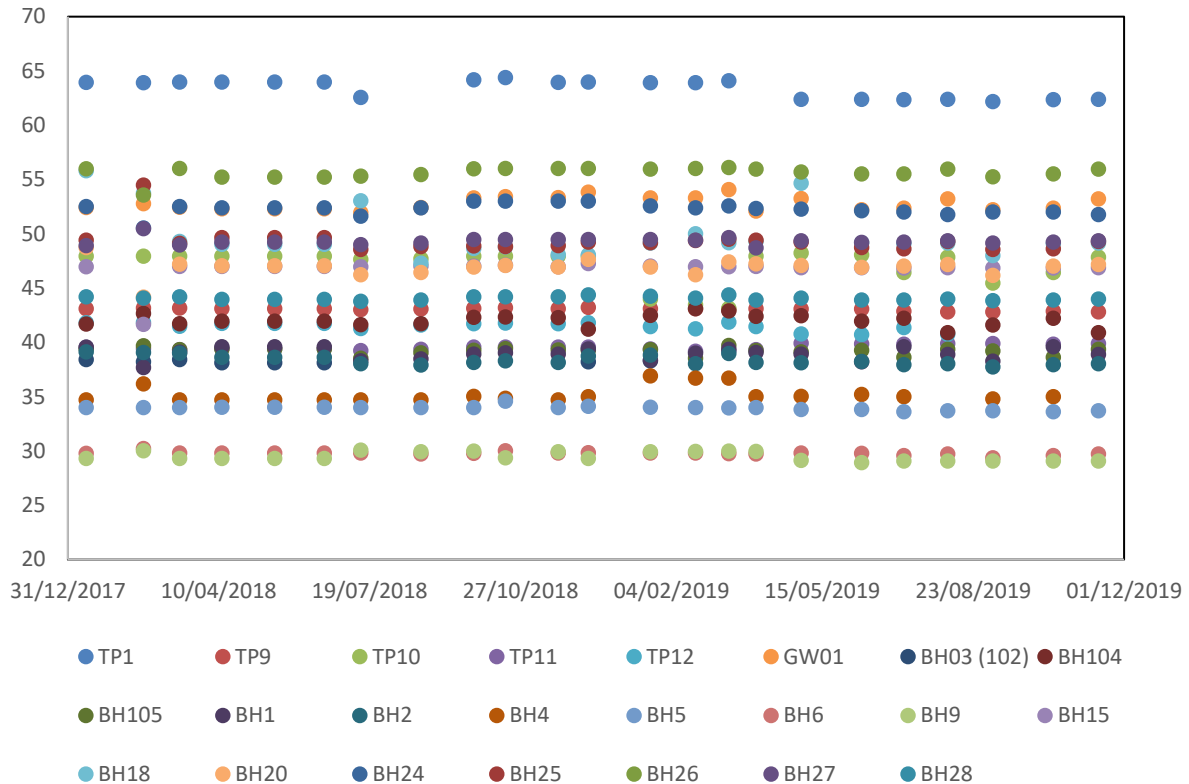
The final restoration contours for Phase 1 are presented in drawing 1111/TP/04:02 (Topographic Survey) and clearly show that the topography of Phase 1 is sufficient steep as to enable surface water to run-off into the surface water management system of drains. As a result, surface water run-on will not be included as an input.

Additionally, as contained in the 2007 water balance, the final restoration profile for Phase 2 will also be sufficiently steep enough that neither surface water run-on or surface water run-off are included in the water balance calculations. However, in accordance with the 2011 review, Cell 5 / 4 South has been engineered with a basal lining system, as such the direct contribution of rainfall will be included for completeness.

4.4 Groundwater Inflow

Groundwater levels for the Site have not materially changed over the period 2017 – 2019 (Figure 2).

Figure 2 Groundwater Levels (mAOD) 2017-2020



Phase 2, and the valley cells, are engineered to ensure a 1m unsaturated zone beneath the site, therefore groundwater inflow is assumed to be negligible and so is not considered within the water balance calculations. There are no rising groundwater levels noted hence the depth of unsaturated zone remains valid.

Cells 11, 13, 14 and 15 of Phase 1 are considered to have an unsaturated zone, of unknown thickness, that will also ensure that groundwater inflow is not applicable for those cells. This is the same as considered within the Golders water balance calculations in the Phase 1 leachate management plan from 2008 and also the leachate management review in 2011.

Cells 1-10 and 12 in Phase 1 are unlined, however the presence of a groundwater cut-off drain means that the majority of groundwater not pass through the waste. Golders estimated that a small quantity of groundwater may pass over the waste in these cells, but it would be of such a small volume as to render it insignificant within the context of the water balance.

4.5 Storage

Previous LMP's defined the absorptive capacity of the waste as the maximum volume of water that can be taken up by the waste from its initial moisture content to field capacity. Golders performed a literature review of absorptive capacities for waste, and used a conservative value of 0.02m²/tonne.

As with the 2007 and 2008 LMP's, the drainable porosity of 6.5% by volume published by Powrie and Beaven (1999)²² was considered however considering the age of waste in Phase 1, and subsequently in older cells of Phase 2, that no absorptive capacity remains. By virtue of not including this within the water balance, the leachate generation is considered a conservative estimate.

The 2007 LMP and 2011 updated stated that the leachate storage volume (as a result of waste saturation) can be estimated by applying the drainable porosity to a saturated volume (equal to the leachate head multiplied by the basal area of each cell). This approach has been adopted to define the amount of leachate in storage at the current compliance limit. A drainable porosity of 4.6% by volume²³ is considered in accordance with the previous submissions.

4.6 Water balance Methodology

Consistent with the 2011 Leachate Management Review, three scenarios have been calculated:

- Average scenario – based on current filling and capping status (average rainfall for a 3 month period)
- Wet Period scenario – same status as above, with average rainfall of 525mm
- Capped scenario – to include all areas of Site with permanent capping (up to Cell 5 North).

The current Site status (including Cell 5 and 4 South) allows a storage volume calculation of 9,924m³ at a 1m head compliance limit. This would appear to be an accurate reflection based on the basal areas at a leachate depth of 1m, the recent leachate levels are provided at Figure 3. Hence for the purpose of the water balance, it is therefor assumed that there is no excess leachate above compliance limits to be removed and therefore the amount of leachate requiring abstraction is equal to the amount generated.

The water balance predicts that under average rainfall conditions 11,499m³ of leachate will be generated in a 3 month period, compared to 23,542m³ during wet conditions.

These estimates provide average and upper limits for annual volume generation of 45,995m³ and 94,167m³ that equate to 128 and 262m³ per day.

Post permanent capping (up to Cell 5 North), daily volumes will reduce to 68m³ per day, it is noted that 3 month volumes generated are less than those predicted in 2011. The updated water balance calculation sheets are provided at Appendix B. The current storage tank capacity at Site 162m³.

Leachate volumes removed from Site between 2010 and 2019 are detailed in Table 3.

²² Powrie, W and Beaven, R.P., (1999). Hydraulic Properties of Household Waste and Implications for Landfills. Proceedings of the Institution of Civil Engineering 137.

²³ Knox, K and Shaw, P.J. 2006. A study of the hydraulic response to landfill to infiltration events. Proc. Conf. Waste 2006.

Figure 3 Leachate Levels (m) – 2014 - 2020

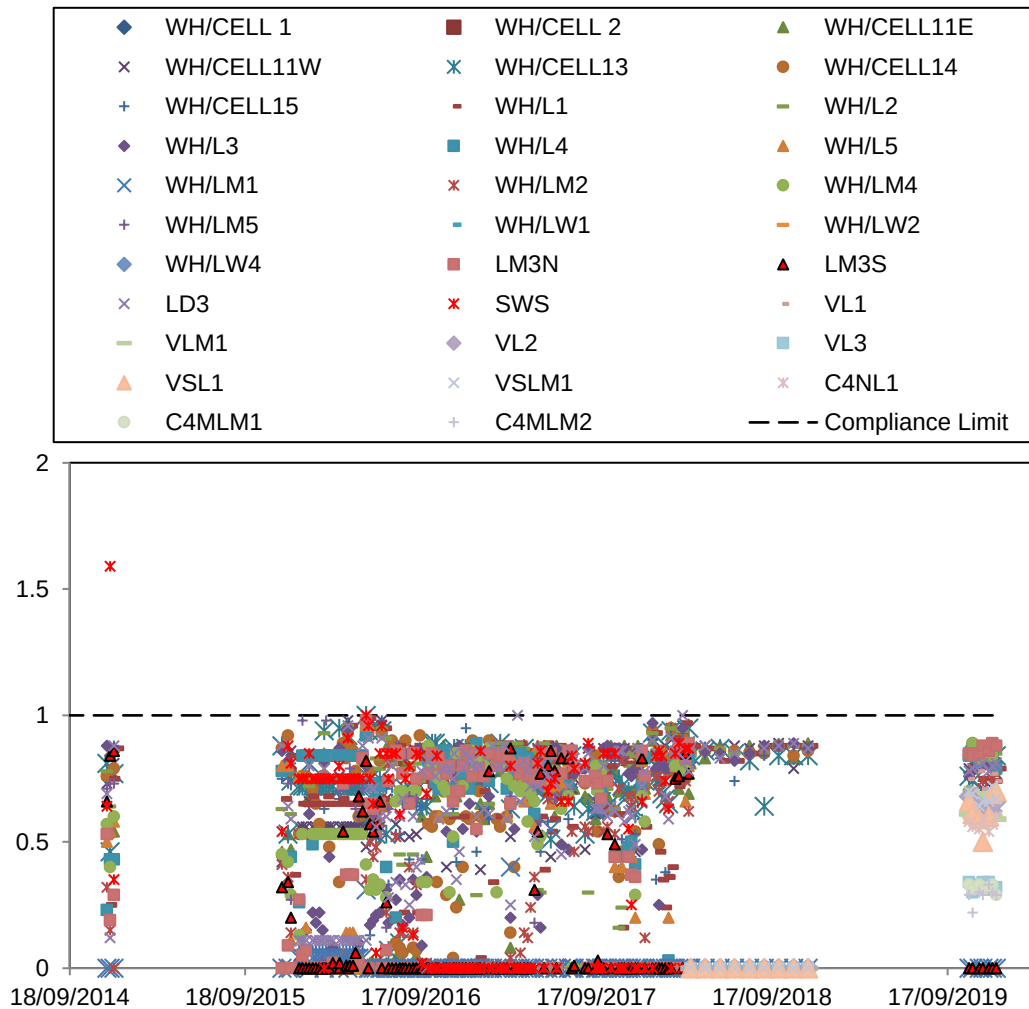


Table 2 Predicted Volumes of leachate during a 3month period (m³)

Phase	Cell	Average	Wet	Capped
1	Cells 1-10, 12	959	959	959
	Cell 11	195	195	195
	Cell 13	186	186	66
	Cell 14	60	60	60
	Cell 15	130	130	130
2	Cell 1 and 2 North	586	586	196
	Cell 1 and 2 South	501	501	141
	Cell 3 South	417	417	117
	Cell 3 North	373	373	133
	Valley Cells	705	705	225
	Cell 4North	2871	8891	131
	Cell 5 North	1775	5498	1031
	Cell 5 and 4 South	2741	5041	2741
	TOTAL	11,499	23,542	6,124

Table 3 Leachate extraction volumes 2010 – 2019 (m³)

Year	Volume of leachate extracted (m ³)
2010	51,283
2011	43,526
2012	52,112
2013	44,655
2014	20,414
2015	48,471
2016	22,391
2017*	14,702
2018*	18,740
2019*	17,126

Information obtained from historic spreadsheets, annual monitoring reviews and weighbridge data*

At average rainfall and calculated infiltration volumes (considered appropriate for the year, ~ 46,000m³) it is evident that between 2010 and 2015 the available volume of leachate for removal was tankered off-site. To account for available absorptive capacity in Cell 3 (not considered utilised in the 2011 LMP review) the excess volume generated in the short term will be recirculated as per the Leachate Recirculation Construction Quality Assurance (CQA) Validation Report²⁴.

The drilling logs included within the CQA validation report (locations highlighted in the supplementary report²⁵) demonstrate that the 30 wells installed encountered “dry wastes” for the majority of the 9m deep installations. The logs did not encounter any wet wastes, as such the Site intends to utilise any remaining absorptive capacity rather than off-site disposal.

4.7 Recirculation Volumes

It is proposed to recirculate 6m³/hr of leachate up to ~20,000m³ /yr, any excess volume (as collected and stored within the leachate tanks) will be progressively removed from Site through existing management and disposal arrangements. There are no proposals to increase leachate head compliance limits. Recirculation documents are provided at Appendix C.

4.8 Leachate Quality Appraisal & review of GW impact from Phase 1

A review of leachate data was provided in the 2019 HRA, the leachate is consistent with expectations for a non-hazardous municipal solid waste landfill. It is a sodium bicarbonate solution, with significant ammoniacal-N, chloride, COD, potassium and recalcitrant organic matter. Calcium, magnesium and sulphate are low compared to the other ions in solution.

The leachate concentration range is consistent with that of many non-hazardous landfills across the UK, the variation in leachate concentrations between Phase 1 and Phase 2 cells is apparent particularly with regard to lower concentrations of ammoniacal-N, alkalinity, TOC, chloride and potassium in Phase 1. This reflects the age of the waste deposited and subsequent waste degradation. Recirculated leachate however will not be segregated from

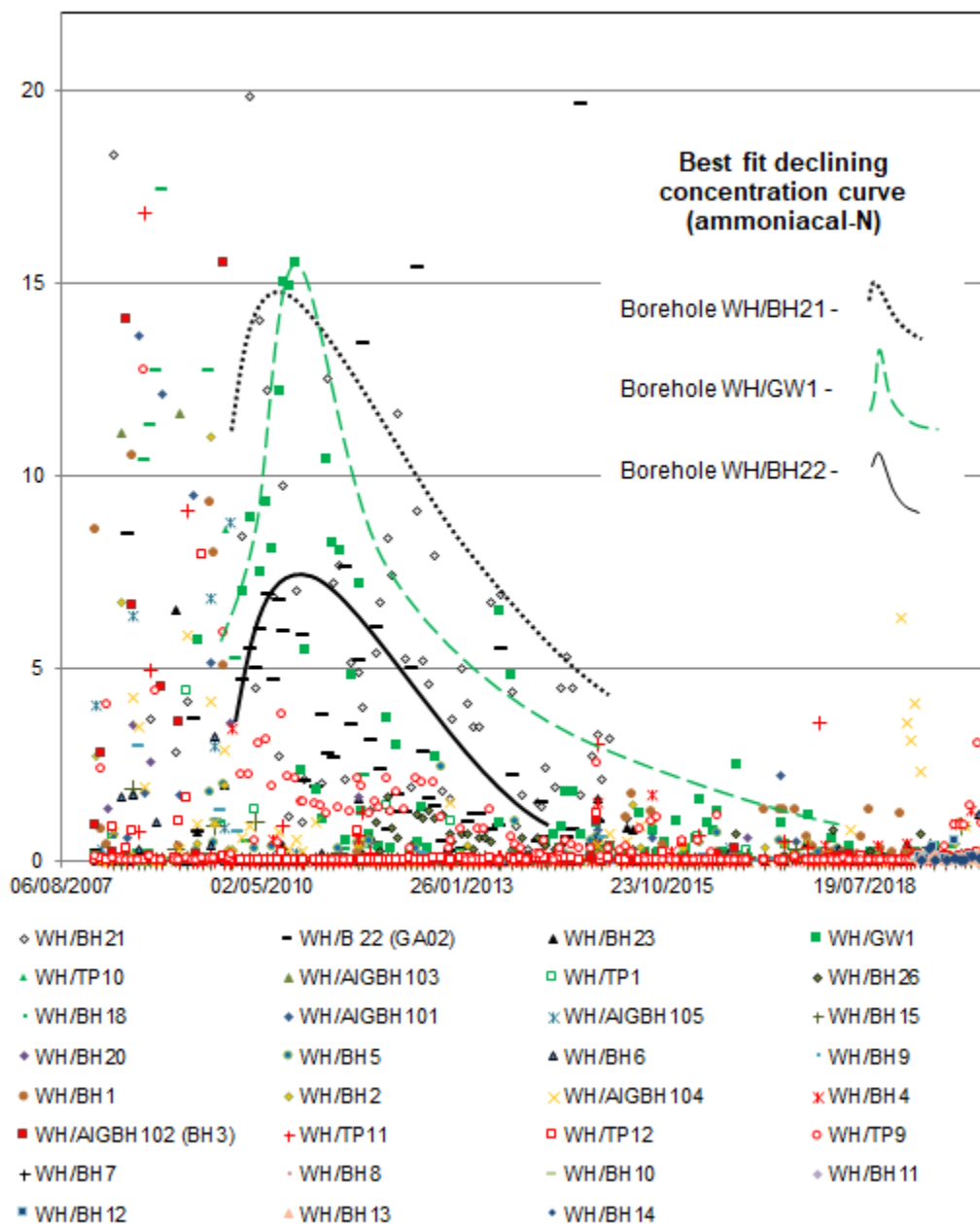
²⁴ Leachate Recirculation Construction Quality Assurance (CQA) Validation Report. Exea Associates Ltd Jan 2017.

²⁵ Leachate Recirculation System. Landfill Solutions - Items requested by NRW during a meeting on 6th Sept 2019 (Nov 2019)

certain areas of Site or specific cells. Recirculated leachate will be taken as a “composite” Site sample as temporarily stored within the 3 storage tanks.

Phase 1 wells (LE1 – LE6) are regularly reported as “dry”. It is important to note however that the area has been capped since the setting of leachate extraction volumes. Current permit requirements are to remove 1,278m³ / year, which compares to a potential infiltration volume of 3,836m³. Although infiltration volumes are calculated as being greater, and current extraction requirements are not being met it is evident that there has been a significant improvement of groundwater downgradient between 2007 and 2015 (Figure 4).

Figure 4 Groundwater NH₄-N (mg/l)



The forthcoming permit variation will seek to amend the current removal requirements.

The recirculation into Cell 3 (Phase 2) will not add to the previously impacted groundwater adjacent to Phase 1 as it is downgradient.

4.9 Migration Pathway Appraisal

The Site has been designed with a 1m “stand-off” between the cells (except Phase Cells 1-10, 12) and underlying groundwater, as demonstrated in Figure 2 there is no material change in groundwater levels monitored over the past 3 years that would indicate a significant change in unsaturated zone thickness. Any short-term variance would be discussed within the next Hydrogeological Risk Assessment update (HRA). The migration pathway (applicable to all cells) has not changed since the production of previous LMP’s.

The upper surface of the weathered Mydrim Shale (unsaturated zone) remains as the transport pathway to groundwater. The lining system has been summarised in section 3.2, the nearest groundwater boreholes BH1 and BH2 (to the Cell 3 recirculation proposal) record average water table levels of 38.8 and 38.2mAOD respectively (2019). The boreholes which are located hydraulically upgradient and downgradient of Cell 3 North respectively are >1m below the base of Cell 3 North with a lowest base elevation at 42mAOD.

Recirculation is not expected to increase the risk to the underlying hydrogeological system, section 5.3 summarises the extraction infrastructure. There are known issues with this infrastructure that would cause management difficulties from the proposed recirculation. With no proposed changes to the leachate compliance limits (and whereby compliance is maintained) there are no additional risks of overtopping and hence no additional risks to the adjacent Rudbaxton Water via an overtopping pathway route.

4.10 Waste types, quantities and filling period

There are no proposals to change the current waste types, Cell 5 North is nearing completion and Cells 5 South (including 4 South as a single cell) are anticipated to be infilled with approximately 242,000m³ of waste.

4.11 Gas & Odour Appraisal

Landfill gas management systems at Site are designed to enable the collection, extraction and treatment of the maximum potential volume of landfill gas generated from a site. The 2014 review included a GasSim model update to account for the infilling of the valley cells. The model suggests that the site is past its peak with peak production modelled at around 1400 M³/hr during 2008. The gas system has been reviewed in accordance with the recirculation proposal²⁶ and has identified that adequate measures are in place to minimise air ingress or egress hence additional odour generation is anticipated to be minimal. Once leachate recirculation is operational, gas production is predicted to double. Systems will be continually reviewed and reported through quarterly reviews that will provide an appraisal of leachate volumes recirculated, gas yield changes and any noted increase in surface emissions. Gas monitoring is proposed to increase to weekly monitoring during the recirculation activity. The site has sufficient gas treatment (flaring) and gas utilisation (gas engine) capacity to deal with the predicted uplift in landfill gas from the recirculation process²⁷ and the operator confirms that the gas collection network in and around the recirculation field is operating effectively.

²⁶ Leachate Recirculation System, ADDENDUM TO THE GAS MANAGEMENT PLAN, Document No. AGMP/WHAug16/02, Landfill Solutions Ltd

²⁷ Landfill Gas Risk Assessment Report 1 (2018) EXEA Associates Ltd

5. LEACHATE MANAGEMENT

5.1 Approach to Leachate Management

This leachate management strategy has been developed from

- an improved understanding of the sites conceptual model with an informed risk based approach to leachate management; and
- a steady state leachate level management / removal by tankering; and will allow;
- recirculation as a sustainable approach to increase gas production

The following provides a summary of the current leachate management strategy.

5.2 Leachate Management Strategy (Phase 1)

Cells 1-10 and 12 of Phase 1 of the landfill were filled prior to the requirements for a landfill liner and leachate management system, and as such are operated on a dilute and disperse basis. This means that there is no engineered leachate management and collection system in place within the cells, a perimeter collection system is available. A summary of the infrastructure is provided in Table 4 and Table 5.

Cells 11, 13, 14 and 15 of Phase 1 have engineered liners and therefore had leachate drainage systems installed within the cells during construction through which leachate can be collected and pumped out of the cells to manage the leachate levels.

Table 4 Phase 1 Extraction Infrastructure (Cell 1-10 and 12) – “LE Series”

Well	Easting	Northing	Datum (mAOD)	Depth (m)	Base elevation (mAOD)	Comment on Drilled Log
LE1	196954.692	221659.368	64.00	16.98	46.15	No leachate encountered
LE2	197071.040	221675.554	63.81	12.97	49.88	Wet household waste
LE3	197160.215	221677.286	60.79	11.50	48.40	Wet household waste
LE4	196915.316	221518.165	66.06	13.80	51.30	Wet household waste
LE5	197069.845	221585.205	65.86	13.10	51.80	Wet household waste
LE6	197162.469	221586.158	63.20	11.30	50.85	Damp household waste

Table 5 Phase 1 Extraction Infrastructure

Monitoring Point	Datum level (mAOD)
Cell 13 Sump	53.33
Cell 11 East	54.51
Cell 11 West	54.52
Cell 14 Sump	52.83
Cell 15 Sump	53.62
LD3	51.67
LW1	62.32
LW2	63.36
LW4	65.46

There are no proposed changes to the management strategy in this Phase.

5.3 Leachate Management Strategy (Phase 2)

All cells within Phase 2 have a full engineering liner and leachate drainage and collection system installed during construction. Again, this facilitates the collection and pumping of leachate from the cells to manage the leachate levels. A summary of infrastructure is provided in Table 6.

Phase 1 (Cells 1 to 10 and 12)

“Leachate is managed within Cells 1 to 10 and 12 by a 300 mm diameter perforated perimeter collection pipe which extends around the southern and eastern perimeter of the Site. The pipework is set within a 20 mm gravel trench. The pipe falls from the southeast corner of Phase 1 from an invert elevation of 54.96 m AOD westwards to an invert elevation of 51.87 m AOD at its closest point to Cell 13 (SW SUMP).

The pipe also falls northwards to the north-eastern corner (LD3). The collection sumps comprise 1200 mm diameter concrete rings set on to a concrete base and tanked using bitumen and bentonite slurry. The perimeter pipe is actively dewatered locally reducing the leachate head to the invert levels. The main objective of this pipe is to prevent leachate breakout along these boundaries of the Site”.

Table 6 Phase 2 Extraction Infrastructure

Monitoring Point	Datum level (mAOD)
C4NL1	43.80
C4NLM1	46.81
C5NL1	40.93
C5NLM2	45.42
C5NLM2	45.83
L1	50.38
L2	49.43
L3	45.17
L4	65.72
L5	64.22
LM1	58.07
LM2	57.26
LM2	53.65
LM3(N)	57.49
LM3(S)	63.85
LM4	67.58
LM5	67.98
LW1	62.32
LW2	63.36
LW4	65.46
VL1	50.93
VL2	56.74
VL2	53.50
VL3	65.99
VLM1	56.24
VLM4	61.96

Phase 1 (Cell 11)

“Spinal leachate collection system falling from the mid-point of the cell towards two leachate collection chambers, Sump B to the west and Sump C to the east, at a gradient of 1 in 50. The collection pipes comprise perforated 150 mm diameter HDPE pipe set within 40 mm gravel. The leachate collection chambers comprise perforated 900 mm diameter HDPE tower and concrete base”.

Phase 1 (Cell 13)

“900 mm diameter central sump at an elevation of 46.5 m AOD, connected to two 150 mm diameter spine drains falling from the cell perimeter towards the sump at a gradient of 1:50. The spine drains are set within 40 mm gravel.”

Phase 1 (Cell 14)

“900 mm diameter sump with concrete base at an elevation of 45 m AOD connected to 150 mm diameter drains in a herringbone pattern falling towards the sump at a gradient of 1:100. The drains are set within 40 mm gravel.”

Phase 1 (Cell 15)

“500 mm thick basal stone drainage blanket into which a herringbone pattern of leachate pipework and extraction sump has been constructed”.

Phase 2 – Area A (Cell 1/2N)

According to the 2008 monitoring review¹³, a 500mm drainage blanket was installed with feeder drains and spine drain. The base of the blanket (lower 150 mm) comprises a 5 to 20 mm gravel overlain by 350 mm of 2 to 125mm gravel⁸. Perforated HDPE pipes feed collection chambers (x2) in the north of the cell.

Phase 2 – Area A (Cell 1/2S)

“The leachate drainage blanket has a total thickness of 300 mm on the base of the cells and comprises natural crushed rock gravel with a typical particle size range of between 10 and 20 mm. The leachate collection and removal system also comprises a network of 150 mm diameter HDPE main spine drain with 100 mm diameter HDPE feeder pipes at a maximum of 50 m centres. In addition, the main spine drain has been connected to the existing pipework of Cells 1 and 2 (North), which are extended through the northern inter-cell bund of Cells 1 and 2 (South). There are also two leachate extraction and two leachate monitoring wells (one of each in each cell)”^{8,16}.

“A non-woven needle-punched geotextile was placed directly above the geomembrane to protect the liner from damage by the gravel drainage layer. A single vertical monitoring and two extraction points (one vertical and one upslope) were installed in each cell. Leachate collection chambers (x2) are located in the north of the cell”⁸.

Phase 2 – Area A (Cell 3)

“The drainage blanket has a total thickness of 300 mm with crushed rock with a nominal particle size between 10 and 20 mm. The leachate system comprises of a 160 mm HDPE main spine drain with 120 mm HDPE feeder pipes at 30 m centres. A leachate collection chamber is located in the north of the cell”⁸.

Valley Cell N1, N2, N3 & S1

The leachate drainage stone installed was a 500mm thick layer with 20 mm - 40 mm screened aggregate. Spine roads of 1000 mm thickness were placed using an excavator, over HDPE pipe with a 184 mm ID. Three leachate extraction points and one monitoring point (VL1, VL2, VL3 and VLM1) were installed (drawing 2185/2/003).

Phase 2 – Area B (Cell 4 North)

The drainage blanket has a thickness of 300mm (20-40mm gravel), with crushed rock with a nominal particle size between 20 and 40 mm. The leachate system comprises of a 160 mm HDPE main spine drain with 120 mm HDPE feeder pipes at 30 m centres. Leachate collection pipework feeds a collection sump, 2 monitoring points have been installed.

Phase 2 – Area B (Cell 5 North)

This is the current Cell. The drainage blanket has a thickness of 300mm (20-40mm gravel), with crushed rock with a nominal particle size between 10 and 20 mm. The leachate system comprises of a 160 mm HDPE main spine drain with 120 mm HDPE feeder pipes at 30 m centres. Leachate collection pipework feeds a collection sump.

Phase 2 – Area B (Cell 4 and 5 South)

This is the next cell under development. Identical leachate drainage infrastructure is proposed as installed in Cell 4 North and Cell 5 North. The drainage blanket will have a thickness of 300mm (20-40mm gravel), with crushed rock with a nominal particle size between 10 and 20 mm. The leachate system will comprise of a 160 mm HDPE main spine drain with 120 mm HDPE feeder pipes at 30 m centres. Leachate collection pipework will feed a collection sump located in the northwest corner of the cell. There is no inter-cell bund proposed.

5.4 Basal Collection – Future Cells

It is assumed that leachate collection points for all future cells will be designed in the same way as previous cells, with a concrete bases for the collection sumps and the base of the cell sloping with drainage media/drains and/or pipework leading to the collection point.

5.5 Zones of Influence

The leachate drainage blanket for each cell should be designed in such a way as to ensure the zone of influence for each leachate extraction point stretches across the whole cell. This enables the whole site to maintain compliance with the 1m leachate head limit.

Golders previously provided a LandSim v2.5 to model to assess whether at the maximum leachate head the leachate extraction system could maintain the compliance level of 1m. The model showed that at the 95th percentile, the maximum leachate head was well below the 1m limit. All future cells will be designed with the same leachate blanket systems, so that the cells can operate within the compliance levels for leachate head.

5.6 Well Design

The well design for all Phase 2 leachate wells will follow the description outlined in the 2007 LMP and the well design for the Phase 1 well are outlined in Golders' 2008 Leachate Management Plan. As with all aspects of this LMP, infrastructure can be assessed where required and updated accordingly. A current survey of all leachate infrastructure is provided on drawing 111/TP/01:01 (dated 29/05/2020).

The following information should be considered for the design; construction; and to ensure the required Construction Quality Assurance (CQA) for all new or replacement leachate wells required at the landfill.

Prior to the installation of any well, the operator will submit a CQA Plan to NRW for their approval. The purpose of this plan is to document a detailed design for each well and the proposed construction methodology.

The following points will be considered when specifying the design of replacement leachate wells:

All Wells

- Prior to installation the location will be identified on the ground taking into account access and any health and safety issues. The location will then be marked out and surveyed. This information will be used to establish the anticipated elevation (and depth) of the top of the basal or side-wall liner in this location from the operator's records. This information will be used to specify the safe drill depth.
- A suitable drilling technique will be selected to ensure that the liner is not penetrated (e.g. incremental drilling) where this is considered a possibility. The criteria used to determine when such a drilling technique will be adopted will be detailed in full.
- A methodology to repair the liner, in the event that it is necessary, will be detailed and will be agreed with NRW in advance of drilling as part of the CQA plan.
- Wells will comprise a perforated well screen and plain access pipe. The specification of the material to be used for the well screen and access pipe (e.g. steel or HPDE) will be justified; and will include consideration of the required lifetime of the well and the cost of replacement.
- The well screen will be surrounded by a non-calcareous filter pack (which should extend at least 1 m above it). The size of the filter pack will be specified based on the purpose of the well and the design of the well screen.
- An appropriate length of bentonite seal must be specified above the filter pack to ensure that there is an adequate seal through the landfill cap.
- The co-ordinates of each well will be surveyed on completion; this will include the elevation of the final datum point that will be used for the on-going measurement of depths down the well (e.g. leachate level, well base and pump position).
- The depth to the base of each well will be measured (using an appropriately weighted device) from the final datum point as soon as possible following the completion of the installation (and in any event within 1 week).
- The construction and installation of all wells will be carried out under the supervision of a suitably qualified CQA supervisor with previous experience of installing leachate wells or environmental monitoring boreholes.
- A validation report containing the installation records will be prepared by the CQA supervisor and submitted to NRW within two calendar months of completion of the work. The CQA supervisor will verify that the details included on each leachate abstraction wells record are accurate. Any design outlined above can be changed through agreement with NRW.

Abstraction wells

- The design of the abstraction wells will be such to maximise the ability to capture and remove leachate from all depths within the waste profile. Perforated well screens will be used accordingly with the exception of the upper part where it is sealed through the landfill cap.
- Abstraction wells will be drilled into the leachate drainage blanket above the concrete base above the liner where possible (Phase 2 only) in order to maximise the leachate abstraction potential.
- Note there is no liner or leachate drainage blanket in the majority of Phase 1; any new abstraction wells located in this area will therefore be drilled as close to the interface between the base of the waste and the underlying bedrock to ensure that the full leachate head can be extracted.

Monitoring wells

- These wells will only be screened in the deeper part of the landfill and sealed against the shallower parts (Phase 2 only). This will ensure that they provide reliable monitoring data for the basal leachate levels. Deep monitoring wells should typically have a well screen no longer than 3 m in length, with the remainder of the well comprising plain pipe.

5.7 Extraction Regime

The leachate extraction regime will remain that same as outlined in the 2007 and 2008 LMP's, which is that a tractor removes the leachate from the sump via a vacuum and transports the leachate to the storage tanks.

5.8 Storage

The leachate storage details have not changed from those described within the previous LMP's.

5.9 Disposal

The off-site disposal of leachate remains unchanged, it will be temporarily stored in above ground tanks before being tankered from site for off-site treatment / appropriate disposal and / or recirculation.

5.10 Recirculation

Excess leachate will be recirculated into Cell 3 (Phase 2). The benefits of recirculating the leachate are that previously unsaturated waste can be re-saturated, thus enabling an acceleration of the stabilisation of the waste. The recirculation infrastructure was installed in January 2017 in accordance with the CQA plan, and validated in the CQA Validation Report²⁴

Based on a recirculation calculation by Landfill Solution Ltd, it was calculated that 30 recirculation wells were required to meet the annual target of 25,000m³ of recirculated leachate. The location coordinates of these 30 recirculation wells are shown in Table 7, wells are installed only across Cell 3 of Phase 2, as identified in the latest topographical survey from January 2020 (Drawing 1111/TP/04:02).

Table 7 Locations of the recirculation wells in Cell 3

Well ID	Latitude	Longitude
1	51.85675	-4.95372
2	51.85663	-4.95415
3	51.85597	-4.95386
4	51.85643	-4.95376
5	51.85659	-4.95417
6	51.85645	-4.95399
7	51.85647	-4.95431
8	51.85624	-4.95408
9	51.89834	-4.89388
10	51.9442	-4.94823
11	51.84892	-4.94588
12	51.85553	-4.95324
13	51.85532	-4.89433
14	51.8707	-4.96463
15	51.87138	-4.91845
17	51.85611	-4.95394
17	51.88339	-4.95771
18	51.87821	-4.87933
19	51.85583	-4.95365
20	51.8557	-4.93551
21	51.85548	-4.95334
22	51.85548	-4.95338
23	51.85585	-4.95332
24	51.85582	-4.95314
25	51.85592	-4.95321
26	51.85603	-4.95336
27	51.85625	-4.95349
28	51.85611	-4.95364
29	51.85595	-4.95345
30	51.85618	-4.95372

Note: all wells drilled to 9m.

A summary of the construction of the recirculation system as details within the CQA validation report is as follows:

- The injection wells are constructed of perforated 200mm HDPE pipework, with the upper section left solid.
- The leachate extraction pipework is constructed with 90mm HDPE pipework, and run from the leachate extraction points to the holding tank cells 1, 2 and 3.
- The recirculation injection wells are backfilled between the HDPE pipework and the waste with non-calcareous stone as per the CQA plan, to a height below ground level sufficient to install a hydrated bentonite seal.
- A 500mm layer of bentonite is installed above the non-calcareous backfill, and a further 200mm of bentonite added until the bentonite seal reached ground level.
- The horizontal collection pipework connecting to the 30 injection wells is constructed with 63mm HDPE pipework.
- There are 10 spurs that feed off the main carrier pipe, each having a pump that feeds the three lines of injection wells.

During the construction of the injection wells, it was noted by the drillers that the majority of the wells were dry down to the base of the injection well (9m below ground), with the waste being described as '*dry, partially rotted waste*'. Wells 1, 2, 3, 5, 6, 7, 11, 15 and 30 having no greater than 2.5m of '*damp, partially rotted waste*' at the base of the injection wells. This signifies that the injection of recirculated leachate will achieve the aim of re-wetting dry waste and as such accelerating stabilisation of the waste mass.

Maintenance of the recirculation system to ensure it is in good usable condition is under contract with Potters RML, and as such Landfill Solutions Ltd will:

- Provide training to key personnel (as detailed by Potters RML) to respond to issues with the recirculation system should there be a need to do so.
- Operation and management of the leachate recirculation system.
- Keep records of the quantities of leachate recirculated into each well.
- Install remote level monitoring equipment into cells where recirculation is taking place. Monitoring will be done on an hourly basis with automatically transmitted alarms sent to LFS and Potters RML.

5.11 Leachate Pre-Treatment

There are no current requirements for pre-treatment of leachate onsite prior to recirculation.

6. MAINTENANCE AND INSPECTION

6.1 Leachate wells

All leachate wells will be inspected as follows:

Weekly

- Check of all pneumatic pumps to ensure that they are working; and if not then action as follows:
 - restart pump using standard procedures for re-activating a pneumatic pump without removing pump from well; and
 - if pump still does not work, then replace with a spare pump at the appropriate depth for the well and return the failed pump to contractor for service/repair.
- Check all pumps to ensure that they are working; and if not then action as follows:
 - attempt to reactivate pump and re-set; and
 - if pump still does not work, then remove from well, inspect and replace with a spare pump and return pump to contractor for service/repair.
- Check that the pulse counters (to give an approximate pumped volume) are working; and if not then repair if possible or replace with a spare.
- Check of well head integrity (for leaks, odours, and air ingress); and if any issues are identified then repair, if possible, otherwise they will be reported to the Site Manager for further action.

As a minimum the following will be recorded during the weekly inspections:

- The date the well was inspected.
- Whether the pump was functioning as anticipated; and if not what steps were taken to re-activate it.
- A record of whether the original pump was removed from the well and the depth at which it (or a replacement) was positioned.
- Details of the replacement pump if one was installed within the well.
- Total volume of leachate abstracted from the well according to the pulse counter.
- Any issues noted with the integrity of the well head and any actions taken. If the issues could not be resolved then details of the further action required will be recorded. These details will then be copied to the Site Manager for further action.

Note that weekly inspection of each pump will ensure that as a maximum there will be a 7 day period between a pump stopping and this being identified. The actions outlined above describe the process that will be undertaken to ensure that such situations are resolved as soon as possible.

To provide an adequate number of spare pumps based on historic failure rates a minimum of two spare pumps will be available on site at any one time in the event that replacement pumps need to be deployed.

Monthly (abstraction wells only)

- The total volume pumped from each abstraction well in the preceding month will be calculated.

6 Monthly (all wells)

- The base of each leachate well will be measured with an appropriately weighted device. The measurement will be compared against the preceding measured depth; in the event that the difference in depth is greater than 0.5 m then the depth will be re-measured. If, after the re-measurement, the indication is that fine material has accumulated on the base of the well then this will be recorded and reported to the Site Manager for further action. If wells are de-silted then the depth before and after the work will be recorded along with a description of the work undertaken and any other relevant observations.

Annually (all wells)

- Annual de-silting as a result of the findings from basal dip readings. If the de-silting exercise still suggests an issue with the well, move to conduct an internal camera survey on the well.

As required (all wells)

- Re-survey the datum point of any well that has its datum point altered or changes are suspected based on the data collected (on an annual basis). Any significant differences will be identified and any necessary changes to datum points will be applied to future measurements (e.g. leachate level) and retrospectively to previous measurements if this is appropriate. Survey all new infrastructure once installed.

Note all measurements of depth down the well (e.g. leachate level, well base, position of pump) will be made with reference to the datum point. All inspection and maintenance records will be collated and retained on site.

6.2 Associated leachate pumping infrastructure

The associated leachate pumping infrastructure will be inspected as follows:

Weekly

- The total volume of leachate abstracted will be recorded and the date and time of inspection.

Monthly

- Check of leachate pipework to assess its integrity. If any issues are identified they should be recorded and repaired if possible. Otherwise any issues will be recorded and reported to the Site Manager for further action.
- Check compressed air pipework to assess its integrity. If any issues are identified they should be recorded and repaired if possible. Otherwise any issues will be recorded and reported to the Site Manager for further action.
- Check that all the equipment is working by confirming that the pumps to the leachate holding tanks, the diffusers, the compressor and the leachate re-circulation pumps are running. If any issues are identified they should be recorded and the equipment should be

re-started if possible. Otherwise any issues will be recorded and reported to the Site Manager for further action.

As required

- The compressor will be serviced in accordance with the manufacturers' instructions (normally after 2000 hours run). Details of servicing undertaken will be recorded.

Staff Training

- 3rd party contractors undertake Site monitoring as required by the Site's Permit and have appropriate accreditation.

7. REMEDIATION

Routine inspections may identify that remedial actions are necessary or in some circumstances that wells or associated infrastructure need to be replaced.

7.1 Leachate wells

Based on the maintenance and inspection schedule there will be one year between internal surveys of the wells and hence this would be the maximum period before any internal failure of the wells is identified. In reality however most failures will be a gradual process and therefore the inability to pump leachate from such a well will not be instant and may be identified much earlier than this from the weekly inspections.

Should any possible failure in the wells be identified then possible options to remediate and save the well will be considered by the operator along with their likelihood of success (e.g. placing protective sleeving around the well to provide additional strength). Any such failure that is identified will be reported to NRW with the proposed remedial measures outlined. The operator will aim to notify NRW of any failure and identify the proposed remedial measures within a 2 week period from identifying that this might be required.

Where it is considered that it is the most effective use of resources to install a replacement well rather than to try to remediate the existing well this will be discussed and agreed with NRW.

7.2 Associated leachate pumping infrastructure

Based on the proposed inspection and maintenance schedule there will be one month between inspections of the infrastructure and hence this would be the maximum period before any issue is identified. In reality however, it is likely that any issues will be identified during ad hoc inspections and any remediation or replacement of infrastructure that is required will therefore be identified earlier than this.

7.3 Recirculation infrastructure

Routine inspections will be undertaken as per the conventional wells / infrastructure. The recirculation system is automated and (when operating) will provide constant feedback in relation to performance.

8. LEACHATE MONITORING AND SAMPLING

8.1 Leachate monitoring and sampling programme

The leachate wells (with a 1m compliance limit) will be monitored in accordance with the current permit. Those in Cell 3 will be monitored at an increased frequency of “weekly” during recirculation at L3, LM3 (North) and LM3 (South).

8.2 Submission of records

A copy of the latest quality assured records of each monitoring or sampling result will be submitted to NRW within 1 calendar month of the results becoming available.

8.3 Leachate level action plan

The Site is currently compliant with leachate level limits of 1m. Liaison between site operations and the local NRW regulation staff would be undertaken in the event that leachate levels are consistently above the compliance level (i.e. 3 consecutive readings above 1m). A monthly email update would be adequate considering the risk profile of the Site. Email notification can be stopped at the agreement of NRW.

8.4 Investigation procedure for breaches of compliance limits

In the event that any compliance level is exceeded in one monitoring well on one occasion, the following action will be taken:

- The well will be re-measured as soon as possible after receipt of the data; if the re-measurement does not exceed the compliance limits then no further action will be taken. If the level is exceeded then:
- NRW will be informed and actions will be considered as described below:
 - Increasing the frequency of leachate level and quality monitoring;
 - Increasing the frequency of groundwater level and quality monitoring; and
 - Consider installing additional leachate abstraction wells;
 - and / or stopping re-circulation until compliance is achieved

The findings of the investigations and any proposed further action will be reported to NRW for agreement.

9. GAS MONITORING AND SAMPLING

9.1 Gas monitoring and sampling programme

During recirculation activities, gas monitoring will increase to “weekly” in accordance with the Gas Management Plan Addendum document.

10. ACTION PLAN

10.1 Leachate Overview

Leachate control is to be provided using the following methodology:

- Leachate recirculation within the landfill mass (proposed);
- Tankering leachate to a suitably licensed treatment facility.

Leachate recirculation will be undertaken in such a way as to avoid the spraying of leachate into the atmosphere, and will be carried out in a manner, which will not impact air quality around the installation boundary or cause odours. Potential effects are minimised by the controlled process proposed as Site.

10.2 Management Review

Management of leachate will be maintained under review by site management, to ensure that as far as is reasonably practicable the leachate collection, treatment and disposal system will have sufficient capacity to handle the maximum predicted rate of leachate generation for the installation and maintain leachate levels in each separately engineered cell below the permit limit.

10.3 Action Plan – Leachate

In the event of leachate level exceedances;

- Resampling of associated wells

NRW will be informed as soon as possible if repeat sampling has indicated an exceedance of the 1m compliance limit.

- If levels remain elevated, a review of recirculation practices will be undertaken and NRW informed of any associated actions / timescales.

10.4 Action Plan – Gas

In the event of air ingress or leaks the following actions are proposed.

- Air Ingress

Air ingress into the system can be caused by a number of different scenarios, such as damage to a wellhead caused by settlement. In the event of such damage being observed, action would be taken to make temporary repairs using sealing tape, pending more permanent repairs, which would be undertaken following isolation of the wellhead or manifold.

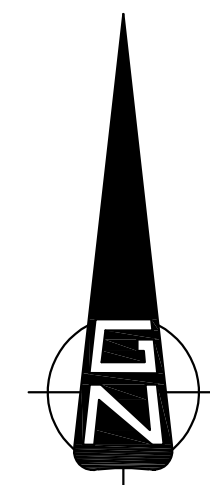
- Leaks

The integrity of the gas system will also be subject to routine monitoring and presence of fixed oxygen analysers at the compound. Any identified problems affecting the operation of the system would be assessed and appropriate remedial actions taken to ensure continued effective control of landfill gas.

The priority would be to undertake temporary repairs using sealing tape if possible pending more permanent replacements or resealing of components.

NRW will be informed as soon as possible if operational / remedial measures are ineffective along with any associated actions / timescales.

Drawings



Point/Line Features (Where Applicable)

- | | |
|---------------------------------|-------------------------|
| Water Meter | Relay |
| Gully | Seat |
| Pit Hydrant | Post |
| Manhole Eye | Brick Sign |
| Earth Road | Paved Bus |
| Stop Valve | Reflective Hazard Post |
| Gas Valve | Traffic Light |
| Air Valve | Telephone Kiosk |
| Electricity Cabinet | Fence |
| Underground Service Marker Post | Safety Fence |
| Telecom Cover | Wall |
| Electric Cover | Gate |
| Inspection Cover (Circular) | Gate |
| Inspection Cover (Square) | Gate |
| Inspection Cover (Rectangular) | Tree |
| Manhole | Tree Hole |
| Electric Pole | Tree Canopy |
| Telephone Pole | Undergrowth |
| Overhead Cable | Hedge |
| Sky Wire Anchor | Permanent Ground Marker |
| Leap Pole | Permanent Boundary |
| Lower Bin | Spot Height |
| | Inset Level |
| | Water Level |

Additional Notes For Fencing

- | | |
|----------------|-----|
| Post and Wire | P/W |
| Post and Rail | P/R |
| Chainlink | C/L |
| Palisade | P/L |
| Close Boarded | C/B |
| Concrete Panel | C/P |
| Safety Fence | S/F |

Building And Floorplan Features

- | | |
|-------------------------|-----|
| Floor Level | FL |
| Damp Proof Course Level | DPC |
| Soffit Level | SOF |
| Eaves Level | EL |
| Ridge Level | RL |
| Threshold Level | THL |
| Sill Level | SL |

Notes



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CLIENT

Potters Waste Management

PROJECT

Withyhedge Landfill

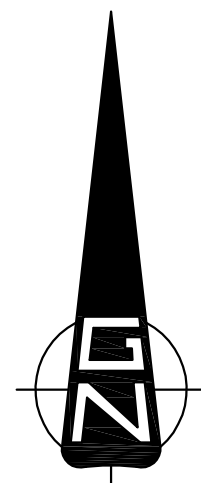
TITLE
Topographic Survey January 2020 (East)

SCALE 1:1000 @ A1	DRAWN BY Newlyn	DATE 05/08/20
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DATE 11/01/20	DATE 24/02/2020
------------------	--------------------

DRAWING REFERENCE
11111/TP/D4.02

REV
0



Point/Line Features (Where Applicable)

- Water Meter
- Gully
- Fire Hydrant
- Flooding Eye
- Gully Hole
- Stop Valve
- Gas Valve
- Air Valve
- Electricity Cabinet
- Person Cover
- Underground Service Manhole Post
- Electric Cover
- Inspection Cover (Circular)
- Inspection Cover (Square)
- Inspection Cover (Rectangular)
- Inspection Cover (Triangular)
- Pylon
- Electricity Pole
- Overhead Cable
- Stop Wire Anchor
- Lamp Post
- Litter Bin

BollardPostRoad SignPost BoxReflective Hazard PostTraffic LightTelephone KioskFencesWallGateGateTreeTree BoltTree CanopyUndergrowthHedgePermanent Ground MarkerPermanent BenchmarkSpot HeightInvert LevelWater Level

Additional Notes For Fencing

- Post and Wire

Post and Rail

Chainlink

Palisade

Close Boarded

Concrete Panel

Safety Fence
- P/W

P/R

C/L

PAL

DB

C/P

S/F

Building And Floorplan Features

- Floor Level

Damp Proof Course Level

Soile Level

Exsels Level

Ridge Level

Threshold Level

Sill Level
- FL

DPC

SOF

EL

RL

THL

SL

Notes

Monitoring Point ID	Datum Level
C4NL1	43.80
C4NLM1	46.81
CSNL1	40.93
CSNLM2	45.42
CSNLM2	45.83
CELL 13 SUMP	53.33
CELL11 EAST	54.51
CELL11 WEST	54.52
CELL14 SUMP	52.83
CELL15 SUMP	53.62
L1	50.38
L2	49.43
L3	45.17
L4	65.72
L5	64.22
LD3	51.67
LE1	64.00
LE2	63.81
LE3	60.79
LE4	66.06
LE5	65.86
LE6	63.20
LM1	58.07
LM2	57.26
LM2	53.65
LM3(N)	57.49
LM3(S)	63.85
LM4	67.58
LM5	67.98
LW1	62.32
LW2	63.36
LW4	65.46
VL1	50.93
VL2	56.74
VL2	53.50
VL3	65.99
VLM1	56.24
VLM4	61.96



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CLIENT
Potters Waste Management

PROJECT
Withyhedge Landfill Site

TITLE
Leachate Monitoring Locations

SCALE
1:1000@A0

SHEET
Newlyn

DATE
OSGB36

DRAWN BY
DB SR

CHECKED BY
DB SR

DATE
29/05/2020

DRAWING SIZE
1111/TP01 : 01

SHEET
01

Appendix A



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REPORT ON

LEACHATE MANAGEMENT PLAN WITHYHEDGE LANDFILL SITE PHASE 1

Submitted to:

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c/o Withyhedge Landfill Site
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Report

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Name

No. Copies

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Golder Associates (UK) Ltd

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Definition of Version Code:

D. Applied during initial drafting of the report before it has been reviewed.

C. Applied after the report has been reviewed but before it has been approved by the Project Manager.

B. Applied after the Project Manager has approved the report ready for issue to the client.

A. Applied to reports after external/client review.

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1.0 INTRODUCTION

1.1 Terms of Reference

Resources Management U.K. Limited (RML) has requested that Golder Associates (UK) Ltd (Golder) produce a Leachate Management Strategy for Withyhedge Landfill Phase 1 (the Site) that is consistent with a Hydrogeological Risk Assessment (HRA).

1.2 Background

Recent poor quality groundwater between Phase 1 and Phase 2 has been investigated (Golder 2007a) and it was concluded that the likely cause was leachate from Phase 1. RML has committed to revisiting the leachate management strategy for Phase 1 and developing it in a way that is consistent with a HRA. That way, leachate management at the site will be protective of groundwater.

1.3 Objectives

The objectives of this work are to provide the Environment Agency with a document that presents a water balance for the Site, a leachate management plan including information regarding extraction, storage and disposal of leachate, and details of the monitoring regime.

1.4 Report Structure

Details of the existing site situation are presented in Section 2.0. The water balance for the Site is presented in Section 3.0, and presents all of the water inputs, outputs and storage characteristics of the Site presented in a water balance spreadsheet model. Section 4.0 presents details of the proposed leachate management, including well location and design, and plans for storage and disposal of leachate. Section 5.0 presents the leachate monitoring regime along with a contingency action plan in the event of elevated leachate levels. Section 6.0 presents the summary and recommendations from the report.

2.0 EXISTING SITE SITUATION

The Site is located approximately 5.5 km north of Haverfordwest in Pembrokeshire at National Grid Reference SM 970 217. It is bounded to the north by Rudbaxton Water, to the east and south by agricultural land and the west by the Phase 2 landfill.

The Site operated as a non-hazardous waste landfill, and has not accepted hazardous waste since 16 July 2004. Phase 1 accepted its final waste in December 2006.

Phase 1 covers an area of 17.8 ha and has a total of fifteen cells. Much of the Site operated on a dilute and disperse basis (Cell 1-10 and 12), however, four of the landfill phases (Cell 11, 13, 14 and 15) have been engineered with artificially established mineral barriers. The exact layout of Cells 1 to 10 and 12 is unknown. The layout of the Site and the phasing of waste deposition are presented in Drawing LMP1.

The existing capping of Phase 1 comprises an overlapped geomembrane and clay composite, onto which subsoil and topsoil restoration materials are placed. The western area of Cells 1 to 11; Cell 13; Cell 14; and Cell 15 in Phase 1 have not yet been capped. The uncapped area is approximately 77,000 m². Permanent capping is currently proposed to comprise a welded geomembrane overlain by a protection geotextile and 1.0 m thick restoration soils. Capping is scheduled for completion by the end of 2007.

3.0 SITE WATER BALANCE

3.1 Introduction

A water balance calculation has been undertaken to consider the potential for generation of excess leachate at the Site (the volume requiring removal) and therefore whether the capacity of the leachate storage and disposal system is sufficient.

This water balance aims to compare the quantities of water entering and leaving the waste during each year. Any imbalance between water input and water output will lead to a change in the quantity of liquid held in the waste as leachate.

Water is present in the landfill either as free leachate or absorbed onto or into solid waste materials. The amount held in each form depends on the storage characteristics of the waste. This varies depending on the type, source and age of the waste.

The water balance calculations are based on the standard water balance equation for any hydrologic system, where the rate of inflow minus the rate of outflow is equal to the rate of change of the quantity of water stored within the system. In its application to a landfill system, this equation is rearranged and combined with assumptions about the volume and storage characteristics of the waste. The volume of free leachate in a specified time period can be calculated using the following equation:

$$V_L = V_{(in)} - V_{(out)} - AW$$

Where

- V_L Volume of free leachate in the landfill system (m^3)
- $V_{(in)}$ Volume of water entering the landfill system (m^3)
- $V_{(out)}$ Volume of water leaving the landfill system (m^3)
- A Absorptive capacity of the waste ($m^3/tonne$)
- W Waste input during the specified time period (tonne)

Water may enter the landfill as a result of effective rainfall, surface run-on, groundwater discharge, and leachate recirculation. Water can leave the landfill by evaporation, transpiration, surface run-off, surface seepage or springs, groundwater recharge, and leachate removal.

3.2 Components of the Water Balance

3.2.1 Effective Rainfall

Effective rainfall is commonly the major input to the water balance. It is defined as the amount of rainfall available for infiltration after run-off and evapotranspiration losses have

been taken into account and any soil moisture deficit has been satisfied. A soil moisture deficit evolves as a result of an excess of evapotranspiration over rainfall.

Final capping works are due to be completed by the end of 2007. It has therefore been assumed for the purpose of the water balance that the Site is permanently capped. Based on the permanent cap specification for the Site (LLDPE geomembrane), the effective rainfall infiltrating the waste is assumed to be 30 mm per year for permanently restored phases, in accordance with the HRA (Golder 2007b).

3.2.2 Surface Water Run-Off

Surface water management for Phase 1 comprises surface water collection ditches around the perimeter of the Site and two surface water collection lagoons located along the northern site boundary. These lagoons discharge into Rudbaxton Water.

The final restoration profile will be sufficiently steep so as to encourage run-off. Surface water run-on is therefore not included in the inputs and surface water run-off is not included in the outputs.

3.2.3 Groundwater Inflow

An unsaturated zone is present beneath engineered Cells 11, 13, 14 and 15, however at maximum water levels, the unsaturated zone thickness reduces to 0.1 m in parts of these cells. Based on a reported cell base of 47 to 48 m AOD in Cells 1 to 10 and 12 (AIG, 2003) it is likely that in some parts of these cells there is no unsaturated zone, particularly during times of higher groundwater levels. It is considered that despite potential periods of groundwater inflow in Cells 1 to 10 and 12, it will be an insignificant volume compared to recharge from rainfall and will therefore not be included in the water balance.

3.2.4 Storage Characteristics

As water percolates down through the Site, it may be absorbed by the porous components of the waste. Waste at field capacity is defined as the maximum amount of moisture that can be held by the waste against the pull of gravity. The absorptive capacity is defined as the maximum amount of water that can be taken up by the waste to take it from its initial moisture content to field capacity.

Waste has been uncapped for over 15 years. It is therefore assumed that there is no remaining absorptive capacity in the waste.

Where free leachate is present across the base of the Site, waste is saturated. The difference between the volume of water retained at field capacity, and that present at saturation is known as the drainable porosity. This has been used to estimate the available leachate storage resulting from saturation of the waste to the leachate compliance level (1 m above the base of the cell for Cells 11, 13, 14 and 15). A drainable porosity of 6.5% by volume has been assumed based upon work by Powrie and Beaven (1999). A leachate storage volume in each cell as a result of waste saturation has been estimated by applying this to a saturated volume equal to the basal cell area multiplied by the leachate head.

3.3 Water Balance Methodology

The water balance calculation has been undertaken using an Excel spreadsheet. The calculations spreadsheets are shown in Appendix LMP1. For each year, the spreadsheet calculates the volume of leachate being produced within each cell (in the absence of any absorptive capacity, equal to the volume of water entering the cell).

The Waste Management Licence (WML) for the Site requires leachate levels to be below the compliance level of 1 m above the base of the cell in all lined cells (Cells 11, 13, 14 and 15). The permitted volume of leachate is calculated for each cell based upon the basal area and the drainable porosity. Any leachate volumes in excess of this permitted volume are calculated from the leachate volume generated. It is assumed that the full excess volume is removed each year and any leachate volumes at or below the permitted volume are carried over to the next year. In the absence of current monitoring data regarding the leachate levels in the lined cells, it is assumed for the purpose of the water balance, which requires an initial leachate level to be input, that at the start of 2008 leachate levels are equal to the compliance head of 1 m.

For unlined Cells 1 to 10 and 12, the HRA (Golder, 2007b) proposed, via results of modelling, that the most appropriate method for regulating leachate was to set a compliance level for leachate based upon a volume of leachate requiring removal per year. The proposed abstraction volume is equivalent to 10 mm per year of infiltration, which based on a surface area of 12.782 ha corresponds to a leachate volume of 1278 m³ per year.

3.4 Summary of Results

The water balance has been used to predict the abstraction requirements to ensure that leachate levels are within the trigger levels. The total leachate abstraction requirements for each year predicted are presented in Table LMP1.

Table LMP1: Leachate Abstraction Requirements

Year	Leachate Volume (m³/yr)	Leachate Volume (m³/week)
Cells 1 to 10, 12*	1278.0	24.6
Cell 11	780.0	15.0
Cell 13	260.1	5.0
Cell 14	240.0	4.6
Cell 15	518.4	10.0
TOTAL	3076.5	59.2

**Volume determined from risk based modelling in HRA (Golder, 2007b)*

The water balance predicts that a rate of around approximately 59 m³ per week (8.5 m³ per day) will be required to maintain compliant leachate levels.

It should be noted that volumes estimated in the water balance are based upon a constant infiltration rate across the Site. In reality, infiltration will vary seasonally due to rainfall and therefore it is likely that leachate generation will increase during winter months. The leachate volume per week is therefore an average required extraction volume and may increase and decrease on a seasonal basis.

4.0 LEACHATE MANAGEMENT

4.1 Leachate Extraction Plan

4.1.1 Extraction Requirements

Leachate will be extracted from the Cells 11, 13, 14 and 15 to maintain the level of leachate within each cell at no greater than 1 m above the base of the cell in accordance with the WML.

As determined from risk based modelling within the HRA (Golder, 2007) removal of a volume of 1278 m³ from Cells 1 to 10 and 12 per year should ensure protection of the surface water environment. In order to successfully abstract this volume of leachate from Cells 1 to 10 and 12, it will be necessary to install a well field in Cells 1 to 10 and 12. It is proposed at this stage to retro-fit six wells, which would mean an abstraction rate of 0.024 m³/hr from each well would be required. This is considered realistic, providing the wells are of sufficient diameter.

The following sections provide details of the location, structure and pumping regime for the leachate extraction system.

4.1.2 Basal Collection System

Leachate is currently managed within Cells 1 to 10 and 12 by a 300 mm diameter perforated perimeter collection pipe which extends around the southern and eastern perimeter of the Site. The pipework is set within a 20 mm gravel trench. The pipe falls from the southeast corner of Phase 1 from an invert elevation of 54.96 m AOD westwards to an invert elevation of 51.87 m AOD at its closest point to Cell 13 (SW SUMP). The collection sumps comprise 1200 mm diameter concrete rings set on to a concrete base and tanked using bitumen and bentonite slurry. The perimeter pipe is actively dewatered locally reducing the leachate head to the invert levels. The main objective of this pipe is to prevent leachate breakout along these boundaries of the Site.

Formal leachate drainage systems have been installed at the point of construction within Cell 11, Cell 13, Cell 14 and Cell 15.

In Cell 11 a spinal leachate collection system has been constructed falling from the mid point of the cell towards two leachate collection chambers, Sump B to the west and Sump C to the east, at a gradient of 1 in 50. The collection pipes comprise perforated 150 mm diameter HDPE pipe set within 40 mm gravel. The leachate collection chambers comprise perforated 900 mm diameter HDPE tower and concrete base (CL Associates, 1995).

In Cell 13 there is a 900 mm diameter central sump at an elevation of 46.5 m AOD, connected to two 150 mm diameter spine drains falling from the cell perimeter towards the sump at a gradient of 1:50. The spine drains are set within 40 mm gravel (AIG, 2001).

In Cell 14 a 900 mm diameter sump with concrete base has been constructed at an elevation of 45 m AOD connected to 150 mm diameter drains in a herringbone pattern falling towards the sump at a gradient of 1:100. The drains are set within 40 mm gravel (AIG, 2002).

In Cell 15 leachate drainage comprises a 500 mm thick basal stone drainage blanket into which a herringbone pattern of leachate pipework and extraction sump has been constructed (AIG, 2004).

Any leachate pipework which is required for extension or repair of the leachate collection system will be delivered, handled, and stored in accordance with the manufacturer's recommendations and in such a way that damage will not occur to any material. The pipes will be stored in an area flat enough to accommodate the entire length of the pipes and in such a way so that they are not deformed or damaged. The pipes will not be stacked higher than 1 m.

Confirmation of the quality control procedures taken by the pipe manufacturer and copies of quality control certificates will be provided to RML.

4.1.3 Leachate Drainage Assessment

The performance of the leachate drainage systems within Phase 1 have been assessed using Landsim v2.5 (Environment Agency, 2003) for Cell 15 and Cell 14 to determine the maximum likely leachate head and therefore the ability to maintain the leachate head beneath the Compliance Level of 1 m. Cell 14 comprises a herringbone pattern of pipes flowing to a sump and Cell 15 comprises a leachate drainage blanket.

4.1.3.1 Cell 14

The slope of the cell base of Cell 14 towards the spur drains was measured to be 1 in 120 from the as built drawing and the slope of pipes to the spine drain was measured to be 1 in 216 from the as built drawing. The pipes are set within the waste and therefore the hydraulic conductivity of the drainage blanket was based upon values for waste from Powrie and Beaven. A range of 3×10^{-6} m/s to 2×10^{-5} m/s was used, based on a waste thickness of 6 to 12 m.

The model output from *WithyhedgePhase1Cell14drainage.sim* (Appendix LMP2) is summarised in Table LMP2.

Table LMP2: LandSim Output Summary of Leachate Drainage System Performance for Cell 14

Cell 14	Maximum Head on Engineered Barrier System (EBS) (m)	
	50%ile	95%ile
	0.29	0.55

20% pipe failure rate is assumed (Golder judgement)

The model results above indicate that the leachate head can be maintained below a 1 m head in Cell 14.

4.1.3.2 Cell 15

The slope of the base of Cell 15 towards the spur drains was measured to be 1 in 75 and the slope of the pipes to the spine drain was measured to be 1 in 100 from the as built drawing. The pipes are set within a 0.5 m thick gravel drainage blanket, the hydraulic conductivity of which is between 1×10^{-4} m/s and 1×10^{-3} m/s.

The model output from *WithyhedgePhase1Cell15drainage.sim* (Appendix LMP2) is summarised in Table LMP3.

Table LMP3: LandSim Output Summary of Leachate Drainage System Performance for Cell 15

Cell 15	Maximum Head on Engineered Barrier System (EBS) (m)	
	50%ile	95%ile
	0.06	0.09

20% pipe failure rate is assumed (Golder judgement)

The model results above indicate that the leachate head can be maintained below a 1 m head and within the drainage blanket in Cell 15.

4.1.4 Well Design

The structure of current leachate extraction sumps in Cells 11, 13, 14 and 15 are shown on Drawing LMP2.

Approximate locations of six proposed leachate abstraction wells in Cells 1 to 10 and 12 are indicated on Drawing LMP1. Final locations and well design will be proposed in a CQA Plan. These wells will also be used for leachate monitoring.

The leachate extraction wells shall be a retro-fitted HDPE well liner. The diameter of the well should be a minimum of 450 mm. The bottom 3 m of the liner shall be perforated to allow ingress of leachate into the chamber. The basal section of the well liner shall be fitted with a solid end cap, and the well liner will be surrounded by an appropriate non-calcareous gravel pack to provide a minimum of 75 mm surround around either side of the well liner pipework. The exact construction details for the wells will be proposed in a CQA Plan and submitted to the Agency for approval.

The retro-drilled wells will be drilled to sufficient depth to allow compliance with leachate compliance levels to be met.

Since containment in the base of Cells 1 to 10 and 12 does not rely on an installed lining system, the retrospective drilling of wells can be undertaken without danger of compromising the liner. If required, the retro-drilled wells can be drilled through the waste until contact is made with the underlying solid strata, ensuring that the leachate abstraction wells extend to the base of the waste. An up to date record will be kept of the exact length of drilling equipment in the hole to ensure accuracy with regard to borehole depth. It is likely that leachate will be encountered which could make the sides of the borehole become unstable, casings may therefore be installed in order to support the sides of the hole.

Once the wells have been drilled, it is recommended to review the extraction regime and monitoring data for a minimum period of six months and assess the necessity for further leachate abstraction and monitoring points in Cells 1 to 10 and 12.

4.1.5 Leachate Extraction Regime

Currently, leachate is extracted from leachate wells by means of a tractor and vacuum tanker with a nominal capacity of 2800 gallons. The tractor removes the leachate from the sump under vacuum and then transports the load to the storage tank where the leachate is then blown under pressure into the tank. Currently between 10 and 17 m³ per day is typically extracted from each lined cell. On average 5 m³ per day is extracted from the two sumps (LD3 and SWSUMP) at either end of the perimeter drain of Cells 1 to 10 and 12. This is currently found to be adequate for Cells 1 to 10 and 12 to keep the leachate levels below the compliance level. This frequency may increase should there be a prolonged period of inclement weather. Leachate abstraction volumes supplied by RML for the period October 2006 to September 2007 are presented in Table LMP4.

Table LMP4: Leachate Abstraction Rates (October 2006 to September 2007) (m³)

	Total	Cell 13 Extraction Sum	Cell 14 Extraction Sum	Cell 14 Temporary Sump	Cell 15 Extraction Sum	S W Sump in Peripheral Leachate Drain	LD3 (in Peripheral Leachate Drain)
October 2006	1627.5	400.0	236.4	209.1	509.2	263.7	9.1
November 2006	1718.4	600.1	90.9	200.0	563.7	227.3	36.4
December 2006	-	-	-	-	-	-	-
January 2007	2336.6	1136.5	18.2	263.7	681.9	190.9	45.5
February 2007	1800.2	881.9	0.0	400.0	391.0	90.9	36.4
March 2007	1818.4	800.1	209.1	254.6	363.7	145.5	45.5
April 2007	881.9	172.7	263.7	45.5	354.6	45.5	0
May 2007	1136.5	318.2	218.2	63.6	409.1	118.2	9.1
June 2007	1195.6	363.7	254.6	90.9	363.7	118.2	4.5
July 2007	1763.8	818.3	190.9	136.4	409.1	200.0	9.1

	Total	Cell 13 Extraction Sum	Cell 14 Extraction Sum	Cell 14 Temporary Sump	Cell 15 Extraction Sum	S W Sump in Peripheral Leachate Drain	LD3 (in Peripheral Leachate Drain)
August 2007	1118.3	381.9	218.2	54.6	336.4	118.2	9.1
September 2007	909.2	236.4	118.2	18.2	491.0	36.4	9.1
Total m³/yr	16306.5	6109.8	3555.0		4873.3	1768.4	
Total m³/week	313.6	117.5	68.4		93.7	34.0	
Total m³/day	44.7	16.7	9.7		13.4	4.8	

At present no plans to change the method of leachate extraction have been made. However, once the full leachate extraction system in Phase 1 is operational, installation of submersible pumps and associated pipe work may be required. This will be reviewed following six months of full leachate abstraction and subsequently on an annual basis and any appropriate changes implemented where necessary.

The water balance for the Site presented in Section 3.4 shows that the current disposal rates will be more than adequate to control leachate levels in all Cells. The predicted leachate volumes requiring removal following capping are presented in Table LMP1.

4.2 Leachate Storage

Leachate is to be stored prior to disposal in a leachate storage tank located to the east of Phase 1. Leachate from both Phases 1 and 2 can be stored within this same tank. The leachate storage tank is a 23,000 gallon (105 m³) capacity steel tank, on an engineered clay base and surrounded on three sides by a clay bund. The clay base falls towards the bunded end and has a capacity of approximately 50,000 gallons. All filler pipes, vents, outlet pipes are kept within the bunded area.

Leachate will be pumped from the Site by vacuum tanker and leachate will then be transferred into the holding tank by pumping directly from the vacuum tanker. Any build up of rainfall within the bund is removed by vacuum as and when required.

The tank will be inspected at weekly intervals and prior to transfer of leachate. If the tank is found to be damaged such that a leak may occur, or is leaking, then arrangements will be made immediately to have the tank repaired. If the tank is found to be leaking following commencement of leachate transfer, then the leachate transfer will cease pending repair of the tank.

The tank bund and clay base will be inspected at weekly intervals and prior to leachate transfer. If the bund or base is found to be damaged such that a leak may occur, then arrangements will be made immediately to have the bund or base repaired.

If the bund is found to be leaking, then immediate measures shall be taken to have the bund emptied to minimise further leakage and appropriate measures shall be taken to clear any contamination of ground outside the tank bund. This may include, use of absorbent materials to contain and absorb spillages, or excavation of contaminated ground and disposal as appropriate. Used absorbent material will be excavated and transferred to containers for disposal at an appropriate facility. Where both the tank and the bund are found to be leaking, then immediate arrangements will be made to have the leachate tank contents emptied into other containers or tanks.

Details of the weekly inspections of tanks, bunding and repairs, or remedial measures taken in event of spillage will be recorded in the Site diary.

Volumes of leachate extracted from Phase 1 (including Cells 1 and 2 North in Phase 2) between October 2006 and September 2007 have been between 882 and 2337 m³ per month (28 m³ to 75 m³ per day). The water balance predicts that a total volume of 8.43 m³ per day will require abstraction from Phase 1 once it entirely capped. Providing leachate abstraction in Phase 2 does not exceed 96.6 m³ per day and tankering off-Site occurs daily, the leachate tank will have sufficient capacity. As Phase 2 expands and further cells become operational, greater leachate storage capacity may be required. The capacity for leachate storage should be reviewed on an annual basis.

4.3 Leachate Disposal

Leachate will be removed from the leachate collection sumps and will be temporarily stored in the above ground storage tank. It will be tankered from site for off-Site treatment and disposal at an appropriate facility.

4.4 Inspection and Maintenance

Maintenance of the pre-engineered leachate containment, collection and monitoring systems should be a priority at the Site. The most valuable asset at a site for the control of leachate is a fully functioning engineered leachate management infrastructure. At Withyhedge this consists of the basal leachate drainage and collection system, leachate extraction and monitoring wells, and the leachate storage tank.

Full historic CQA documentation of these elements will be maintained. Further records will be maintained of the construction details of any future retro-fitted leachate pumping and monitoring structures to include as a minimum the location, construction details, basal level, and top datum.

When any failures in the leachate collection infrastructure are found these should be remediated as quickly as possible. The most common form of failure is blockage or collapse of leachate pumping or monitoring structures.

Inspection and maintenance activities include the following actions:-

- Weekly inspection of leachate chambers for evidence of damage and the repair of damaged items to ensure that the integrity of the system is maintained;
- Review and assessment of leachate extraction and monitoring riser pipes to assess suitability for use, and retro-drilling of pipes where excessive deflections or blockages occur; and
- Inspection and remedial measures (e.g. jetting or use of a ‘guzzler’) to extraction pipework, when necessary, to maintain the ability to control leachate levels.

5.0 LEACHATE MONITORING

5.1 Monitoring Infrastructure

In Cells 11, 13, 14 and 15 leachate will be monitored from the leachate extraction sumps. It is proposed that six additional extraction/monitoring wells are installed within Cells 1 to 10 and 12 to facilitate compliance with respect to leachate volume removal. Abstraction from the sumps at either end of the perimeter drain will continue until such time as the new wells are installed. The locations of leachate monitoring wells are shown on Drawing LMP1.

Locations which will be used for leachate monitoring and sampling are given in Table LMP5:

Table LMP5: Leachate Monitoring Locations

Cell	Leachate Extraction Well	Leachate Monitoring Well
1 to 10 and 12	LW1, LW2, LW4, LD3, SW SUMP, L1, L2, L3, L4, L5, L6	LW1, LW2, LW4, L1, L2, L3, L4, L5, L6
11	Sump B and Sump C	Sump B and Sump C
13	Cell 13 Sump	Cell 13 Sump
14	Cell 14 Sump	Cell 14 Sump
15	Cell 15 Sump	Cell 15 Sump

It is recommended that annual 24 hour pumping cessation tests are undertaken in wells within Cells 1 to 10 and 12 to assess their efficiency.

5.2 Leachate Levels

5.2.1 Compliance Level

In accordance with the findings of the Hydrogeological Risk Assessment, the leachate level within Cells 11, 13, 14 and 15 will be maintained at or below 1 m above the base of the cell.

For the unlined Cells 1 to 10 and 12, a compliance level based on a leachate abstraction volume is proposed. The hydrogeological risk assessment has concluded that in order for concentrations of ammoniacal nitrogen to be acceptable with a high degree of confidence at the point at which water discharges to Rudbaxton Water, a certain volume of leachate requires removal from Cells 1 to 10 and 12. In the HRA a volume for extraction corresponding to 10 mm per year of infiltration was assumed. Based upon a surface area of 12.782 ha, it is therefore proposed that to remain within compliance, 1278 m³ per year of leachate must be abstracted.

5.2.2 Monitoring Schedule

Once each cell is capped, the level of leachate in the boreholes will be monitored on a quarterly basis. Results of leachate level measurements will be forwarded to the Environment Agency on a quarterly basis.

5.2.3 Contingency Action Plan

Given the identified risk of overtopping at the Site and the sensitivity of the adjoining SAC, as outlined in the HRA, a contingency action plan has been developed in order to ensure that risk to surrounding groundwater and surface water is not posed should compliance levels be breached.

The proposed action plan following breach of the compliance level is presented in Table LMP6.

Table LMP6: Proposed Action Plan following Breach of a Compliance Level

1.	Generate internal incident report to assess potential breach.
2.	Report to Environment Agency.
3.	Check that the leachate extraction system is operational and increase monitoring of leachate level to daily. Daily monitoring in the leachate level monitoring point will continue until levels have been reduced. Site management will inspect the Site on a daily basis to ensure that no evidence of leachate breakout is observed. Site management will also inspect the state of the cap.
4.	If initial repeat measurement confirms breach of the compliance level, review site management and operations and commence increased pumping in the relevant leachate extraction points.
5.	If the leachate level cannot be reduced within 7 days of pumping, then discussions will be held with the Agency, and proposals submitted within 14 days for the reduction of leachate in the phase to comply with compliance levels, and will be implemented following approval of the Agency.
6.	If continued breaches occur, review existing hydrogeological risk assessment.
8.	If risks are unacceptable, set in place procedures for implementing permanent corrective measures in consultation with, or required by, the Agency.

5.3 Leachate Quality

5.3.1 Action Levels

The trigger level for List I compounds in water in the shales down gradient of the landfill will be set at the minimum reporting value. As a means of establishing a control level for these substances, an action level for leachate quality for List I compounds cadmium, mecoprop and naphthalene is proposed. Action levels will be developed after a year of leachate monitoring.

5.3.2 Monitoring Schedule

Leachate will be sampled from one monitoring point in each of the cells and analysed as detailed in Table LMP7.

Table LMP7: Leachate Monitoring Frequency and Analytical Determinands

Determinants	Unit	Analysis
Temperature	°C	Quarterly
pH	-	Quarterly
Electrical conductivity	µS/cm	Quarterly
Ammoniacal nitrogen	mg/l	Quarterly
TON	mg/l	Quarterly

Determinants	Unit	Analysis
TOC	mg/l	Quarterly
BOD	mg/l	Quarterly
COD	mg/l	Quarterly
Calcium	mg/l	Quarterly
Magnesium	mg/l	Quarterly
Sodium	mg/l	Quarterly
Potassium	mg/l	Quarterly
Alkalinity	mg/l as CaCO ₃	Quarterly
Sulphate	mg/l	Quarterly
Chloride	mg/l	Quarterly
Mecoprop	µg/l	Quarterly*
Naphthalene	µg/l	Quarterly*
Iron	mg/l	Six Monthly
Manganese	mg/l	Six Monthly
Mercury	mg/l	Six Monthly
Cadmium	mg/l	Six Monthly
Chromium	mg/l	Six Monthly
Copper	mg/l	Six Monthly
Cyanide	mg/l	Six Monthly
Nickel	mg/l	Six Monthly
Lead	mg/l	Six Monthly
Zinc	mg/l	Six Monthly
Phenols	mg/l	Six Monthly
Sulphide	mg/l	Six Monthly
Mineral Oil	mg/l	Six Monthly

* To be analysed for on a quarterly basis until such time as Action Levels are derived.

Analysis, detection limits and reporting of results will be undertaken in accordance with guidance issued by the Agency.

6.0 SUMMARY AND RECOMMENDATIONS

The purpose of this report is to present a Leachate Management Plan for Withyhedge Landfill Phase 1 which accompanies the Hydrogeological Risk Assessment.

6.1 Leachate Management, Storage and Disposal

A Leachate Management Plan has been developed for Withyhedge Landfill Phase 1. The suitability and sustainability of the proposed method of management has been considered by means of a water balance. The water balance provides estimates of the volume of leachate which will require removal on a cell by cell basis.

The water balance predicts that a rate of around 59.2 m³ per week (8.46 m³ per day) will be required to maintain compliance with respect to leachate once the Site is fully capped.

The water balance has concluded that current leachate production rates can be adequately managed by storage and disposal of leachate via tankering off-Site at present. As Phase 2 expands and further cells become operational, greater leachate storage capacity may be required for this phase, reducing the available capacity for Phase 1 leachate. The capacity for leachate storage should be reviewed on an annual basis.

A leachate extraction plan has been provided which presents drawings showing the location, full design and specification of extraction points. Discussion regarding the extraction regime and an assessment of the leachate drainage performance has also been presented. Storage and disposal of leachate has also been included in the report.

6.2 Leachate Monitoring

The leachate level within Cells 11, 13, 14 and 15 will be maintained at or below 1 m above the base of the cell. The compliance level for Cells 1 to 10 and 12 has been set at a leachate abstraction volume of 1278 m³ per year. In order to ensure this volume can be removed efficiently, it is proposed to retro-drill a further six extraction wells in Cells 1 to 10 and 12. A contingency action plan has been developed in order to ensure that risk to surrounding groundwater and surface water is not posed should compliance levels be breached.

6.3 Recommendations

As a Site improvement plan, it is recommended that:

- The requirement for an additional leachate storage tank should be reviewed on an annual basis; and
- Following approval by the Agency of the Hydrogeological Risk Assessment, six abstractions wells should be drilled within Cells 1 to 10 and 12 to facilitate leachate extraction. Following this, the leachate extraction regime should be reviewed after six months.

7.0 REFERENCES

AIG Consultants Limited (2001). Withyhedge Landfill Site Cell 13 CQA Certification Report, UK01/2139/6, December 2001.

AIG Consultants Limited (2002). Withyhedge Landfill Site Cell 14 CQA Certification Report, UK02/2139/4, October 2002.

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AIG Consultants Limited (2004). Withyhedge Landfill Site Cell 15 Construction Quality Assurance Certification Report, UK04/2139/3, October 2004.

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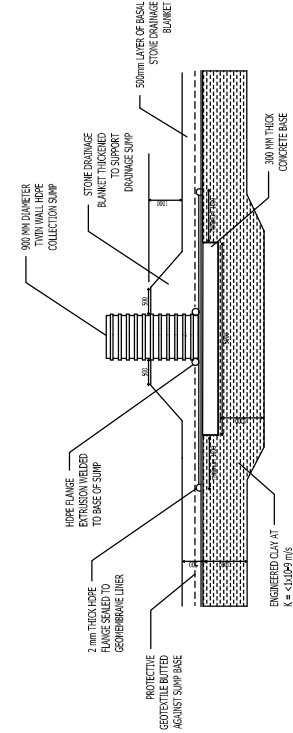
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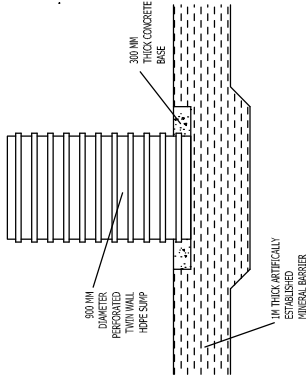
Golder Associates (UK) Limited. (2007b). Withyhedge Landfill Phase 1 Hydrogeological Risk Assessment Ref. 07514290132.500/A.0, November 2007.

Powrie, W. and Beaven, R.P, (1999). Hydraulic Properties of Household Waste and Implications for Landfills. Proceedings of the Institution of Civil Engineering 137, pp 235 – 247.

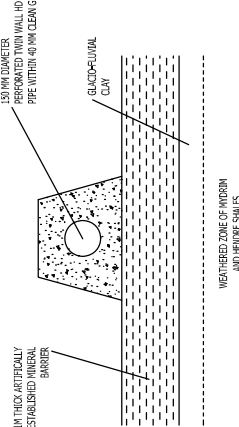
DRAWINGS



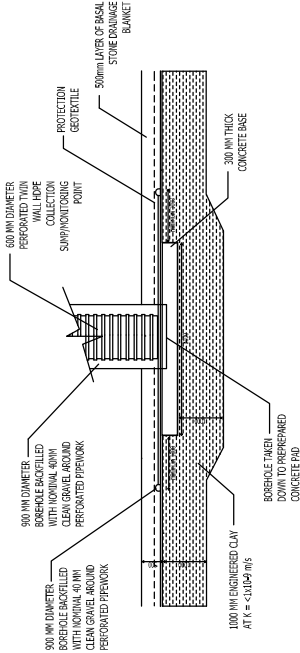
CELL 15 LEACHATE COLLECTION SUMP CONSTRUCTION
Scale 1:125



CELL 11, 13 AND 14 SUMP CONSTRUCTION
Scale 1:100



CELL 13, 14 LEACHATE DRAINAGE
PIPEWORK CONSTRUCTION
Scale 1:100



CELL 15 RETROFITTED SUMP/MONITORING POINT AND
CONCRETE PAD DESIGN
Scale 1:125

REFERENCE

1. Drawing provided by AIG Consultants, Drawing No. 2139/C/15/3, dated 05.07.04



Resources Management U.K. Limited
Withyhedge Landfill, Bowling Farm
Rudbaxton, Haverfordwest SA62 4DB

Project
Leachate Management Plan

Location
Withyhedge Landfill Site

Title
Leachate Management System Construction

Project No. 07514290132	Engineer <i>NC</i>	Drawing No. LMP2
File No. 5228443	Reviewed by <i>DEJ</i>	
Created by C.B.	As shown	Date 31st October 2007
Scale	As shown	Date 31st October 2007



APPENDICES

APPENDIX LMP1

WATER BALANCE

Assumed Cell areas

Area	Basal Area (m ²)	Top Area (m ²)
Phase 1 Cells 1 to 10	91110	127820
Phase 1 Cell 11	9170	26000
Phase 1 Cell 13	6200	8670
Phase 1 Cell 14	5540	8000
Phase 1 Cell 15	12610	17280

Water Balance Summary

Total Site Leachate Volumes Required to be Removed to ensure leachate trigger levels

Cell	Leachate Volume (m ³ /yr)	Leachate Volume (m ³ /week)
Cells 1 to 10, 12*	1278.0	24.6
Cell 11	780.0	15.0
Cell 13	260.1	5.0
Cell 14	240.0	4.6
Cell 15	518.4	10.0
Total for 2008 onwards	3076.5	59.2

* Leachate volume to be removed in Cells 1 to 10 and 12 determined from risk based modelling in HRA (Golder, Oct 2007)

Phase 1 Cell 11

	Code	
Effective Rainfall- Permanent Cap (mm/yr)	Erp	30 mm/yr
Drainable Porosity (fraction)	P	0.065 fraction by volume
Compliance Level for leachate head (m)	Lh	1 m above base

Year		Calculation	2008 onwards
Leachate Volume at Start of year (m ³)	LVto	TLV from previous year - EL from previous year	596.05
INPUTS			
Top Area of Permanently Capped Cells(m ²)	ATpc		26000
Basal Area (m ²)	AB		9170
Volume entering Permanently Capped Cells (m³/yr)	RVpc	Erp/1000*Atpc	780
LEACHATE VOLUMES			
Volume of Leachate Generated in year (m ³)	LG	RVpc	780
Total Volume of Leachate present at end of year (m ³)	TLV	LVto+ LG	1376.05
Permitted Leachate Volume (m ³)	PLV	Lh*AB*P	596.05
Depth of leachate without abstraction (m)	Ld	TLV/(AB*P)	2.31
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE			
Excess Leachate Volume for removal (m ³ /year)	EL	If TLV>PLV, (TLV-PLV), otherwise 0	780
Excess Leachate Volume for removal (m ³ /week)		EL/52	15.00

Phase 1 Cell 13

	Code	
Effective Rainfall- Permanent Cap (mm/yr)	Erp	30 mm/yr
Drainable Porosity (fraction)	P	0.065 fraction by volume
Compliance Level for leachate head (m)	Lh	1 m above base

Year		Calculation	2008 onwards
Leachate Volume at Start of year (m ³)	LVto	TLV from previous year - EL from previous year	403
INPUTS			
Top Area of Permanently Capped Cells(m ²)	ATpc		8670
Basal Area (m ²)	AB		6200
Volume entering Permanently Capped Cells (m³/yr)	RVpc	Erp/1000*Atpc	260.1
LEACHATE VOLUMES			
Volume of Leachate Generated in year (m ³)	LG	RVpc	260.1
Total Volume of Leachate present at end of year (m ³)	TLV	LVto+ LG	663.1
Permitted Leachate Volume (m ³)	PLV	Lh*AB*P	403
Depth of leachate without abstraction (m)	Ld	TLV/(AB*P)	1.65
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE			
Excess Leachate Volume for removal (m ³ /year)	EL	If TLV>PLV, (TLV-PLV), otherwise 0	260.1
Excess Leachate Volume for removal (m ³ /week)		EL/52	5.00

Phase 1 Cell 14

	Code	
Effective Rainfall- Permanent Cap (mm/yr)	Erp	30 mm/yr
Drainable Porosity (fraction)	P	0.065 fraction by volume
Compliance Level for leachate head (m)	Lh	1 m above base

Year		Calculation	2008 onwards
Leachate Volume at Start of year (m ³)	LVto	TLV from previous year - EL from previous year	360.1
INPUTS			
Top Area of Permanently Capped Cells(m ²)	ATpc		8000
Basal Area (m ²)	AB		5540
Volume entering Permanently Capped Cells (m³/yr)	RVpc	Erp/1000*Atpc	240
LEACHATE VOLUMES			
Volume of Leachate Generated in year (m ³)	LG	RVpc	240
Total Volume of Leachate present at end of year (m ³)	TLV	LVto+ LG	600.1
Permitted Leachate Volume (m ³)	PLV	Lh*AB*P	360.1
Depth of leachate without abstraction (m)	Ld	TLV/(AB*P)	1.67
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE			
Excess Leachate Volume for removal (m ³ /year)	EL	If TLV>PLV, (TLV-PLV), otherwise 0	240
Excess Leachate Volume for removal (m ³ /week)		EL/52	4.62

Phase 1 Cell 15

	Code	
Effective Rainfall- Permanent Cap (mm/yr)	Erp	30 mm/yr
Drainable Porosity (fraction)	P	0.065 fraction by volume
Compliance Level for leachate head (m)	Lh	1 m above base

Year		Calculation	2008 onwards
Leachate Volume at Start of year (m ³)	LVto	TLV from previous year - EL from previous year	819.65
INPUTS			
Top Area of Permanently Capped Cells(m ²)	ATpc		17280
Basal Area (m ²)	AB		12610
Volume entering Permanently Capped Cells (m³/yr)	RVpc	Erp/1000*Atpc	518.4
LEACHATE VOLUMES			
Volume of Leachate Generated in year (m ³)	LG	RVpc	518.4
Total Volume of Leachate present at end of year (m ³)	TLV	LVto+ LG	1338.05
Permitted Leachate Volume (m ³)	PLV	Lh*AB*P	819.65
Depth of leachate without abstraction (m)	Ld	TLV/(AB*P)	1.63
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE			
Excess Leachate Volume for removal (m ³ /year)	EL	If TLV>PLV, (TLV-PLV), otherwise 0	518.4
Excess Leachate Volume for removal (m ³ /week)		EL/52	9.97

APPENDIX LMP2

LEACHATE DRAINAGE ASSESSMENT LANDSIM OUTPUTS

Calculation Settings

Number of iterations: 1001

Results calculated using sampled PDFs

Maximum Head Calculation

Clay Liner:

Retarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

Biodegradation

Saturated Vertical Pathway:

No Vertical Pathway

Aquifer Pathway:

Retarded values used for simulation

Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Ammoniacal_N	Non-Volatile
c (kg/l): 0.59	m (kg/l): 0
Cadmium	Non-Volatile
c (kg/l): 0.1589	m (kg/l): 0.0823
Chloride	Non-Volatile
c (kg/l): 0.2919	m (kg/l): 0.0298
Mecoprop	Non-Volatile
c (kg/l): 0.57	m (kg/l): 0
Naphthalene	Volatile
Half life (years): 10	
Nickel	Non-Volatile
c (kg/l): -0.1479	m (kg/l): 0.0987
Phenols	Volatile
Half life (years): 10	

Contaminant Half-lives (years)

Unsaturated Pathway:

Ammoniacal_N	SINGLE(1e+009)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	SINGLE(1e+009)
Naphthalene	SINGLE(1e+009)
Nickel	SINGLE(1e+009)
Phenols	SINGLE(1e+009)

Aquifer Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	SINGLE(1e+009)

Background Concentrations of Contaminants

Justification for Contaminant Properties

No background concentrations used.

Naphthalene and mecoprop half lifes from Howard et al (1991)

Phenol half life from Consim help files

Mecoprop half life from EA (2003)

All units in milligrams per litre

Phase: Cell 14**Infiltration Information**

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(30,3)
Infiltration to grassland (mm/year):	NORMAL(268.1,26.8)
End of filling (years from start of waste deposit):	1
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Cap infiltration for a membrane cap

Grassland infiltration calculated using Grindley method

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	44
Cell length (m):	126
Cell top area (ha):	0.8
Cell base area (ha):	0.5544
Number of cells:	1
Total base area (ha):	0.5544
Total top area (ha):	0.8
Head of Leachate when surface water breakout occurs (m)	SINGLE(6)
Waste porosity (fraction)	UNIFORM(0.49,0.52)
Final waste thickness (m):	UNIFORM(6,12)
Field capacity (fraction):	UNIFORM(0.4,0.43)
Waste density (kg/l)	UNIFORM(0.39,0.49)

Justification for Landfill Geometry

Geometry based on site plans for each cell

Thickness calculated from restoration contours and basal elevations

Field capacity, porosity and density from Powrie and Beaven (1995)

Source concentrations of contaminants*All units in milligrams per litre*

Declining source term

Ammoniacal_N

LOGTRIANGULAR(4.37,723,3640)

Data are spot measurements of Leachate Quality

Cadmium

LOGTRIANGULAR(0.0019,0.0101,0.105)

Substance to be treated as List 1

Chloride

LOGTRIANGULAR(36.6,2270,7760)

Data are spot measurements of Leachate Quality

Mecoprop

LOGTRIANGULAR(0.000253,0.011,0.067)

Substance to be treated as List 1

Naphthalene

LOGTRIANGULAR(0.0001,0.00046,0.011)

Substance to be treated as List 1

Nickel

LOGTRIANGULAR(0.00883,0.12,2.21)

Data are spot measurements of Leachate Quality

Phenols

LOGTRIANGULAR(0.00025,0.012,0.07)

Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate

NH₄, Cl, Cd, Ni and phenol based on site specific leachate quality

Naphthalene and mecoprop from Knox (2000)

Drainage Information

Type of drainage: Piped

Calculate flow from given parameters:-

Sump radius (m):

0

Slope to sump:

1 on 120 (0.48°)

Pipe slope to spine:

1 on 216 (0.27°)

Justification for Ground Slope to Drainage Pipes

Unjustified value

Method of laying pipes:

slopes both ways

Diameter of pipes (mm):

150

Spacing of pipes (m):

50

Failure rate of pipes (fraction):

0.2

Justification for Piping Arrangement

Unjustified value

Drainage thickness (m):

1

Blanket drain conductivity (m/s):

LOGUNIFORM(3e-006,2e-005)

Justification for Drainage Blanket (Piped)

Unjustified value

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
engineered base

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	TRIANGULAR(1.667,1.793,1.934)
Pathway moisture content (fraction):	TRIANGULAR(0.201,0.253,0.338)

Justification for Clay: Liner Thickness
Design thickness and site specific testing

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(2.8e-010,7.7e-010,7.7e-010)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
Conductivity is based on site specific testing
Dispersivity is 10% of liner thickness

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Ammoniacal_N	TRIANGULAR(0.125,0.883,2.4)
Cadmium	TRIANGULAR(127,11147,16657)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Fraction of Organic Carbon (fraction)	UNIFORM(0.001,0.004)

Justification for Liner Kd Values by Species
NH4 and Cd from site specific testing
Ni, phenol and naphthalene from Consim help files
mecoprop from EA (2004)
Foc from site specific testing

Shale pathway parameters*Modelled as unsaturated pathway*

Pathway length (m):	UNIFORM(1,2.5)
Flow Model:	porous medium
Pathway moisture content (fraction):	TRIANGULAR(0.213,0.236,0.292)
Pathway Density (kg/l):	TRIANGULAR(1.785,1.9402,1.979)

Justification for Unsat Zone Geometry

Thickness based on basal levels and groundwater levels

Moisture content and density from site specific testing

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(2.2e-008,4.1e-005)
--	-------------------------------

Justification for Unsat Zone Hydraulics Properties

Falling head test data from within shales

Pathway longitudinal dispersivity (m):	UNIFORM(0.1,0.25)
--	-------------------

Justification for Unsat Zone Dispersion Properties

10% of unsaturated zone thickness

Retardation parameters for Shale pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):	
Ammoniacal_N	LOGUNIFORM(0.02647,0.6929)
Cadmium	TRIANGULAR(694,3927,3927)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.002,0.005,0.019)

Justification for Kd Values by Species

NH4 and Cd from site specific testing

Ni, phenol and naphthalene from Consim help files

mecoprop from EA (2004)

Foc from site specific testing

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(15,145)
Pathway width (m):	SINGLE(97)

pathway parameters

No Vertical Pathway

Shale pathway parameters

Modelled as aquifer pathway.

Mixing zone (m): SINGLE(5)

Justification for Aquifer Geometry

Assumed thickness over which groundwater will flow beneath the site

Darcy flux (m/s): NORMAL(5.52e-007,5.52e-008)

Pathway porosity (fraction): TRIANGULAR(0.213,0.236,0.292)

Justification for Aquifer Hydraulics Properties

Darcy flux based on upgradient recharge resulting in underflow.

Porosity based on typical values for shales

Pathway longitudinal dispersivity (m): UNIFORM(0.75,33.5)

Pathway transverse dispersivity (m): UNIFORM(0.225,10.05)

Justification for Aquifer Dispersion Details

Longitudinal dispersivity 10% of aquifer pathway

Transverse dispersivity 3% of aquifer pathway

Retardation parameters for Shale pathway

Modelled as aquifer pathway.

Uncertainty in Kd (l/kg):

Ammoniacal_N

LOGUNIFORM(0.02647,0.6929)

Cadmium

TRIANGULAR(694,3927,3927)

Chloride

SINGLE(0)

Mecoprop: Calculated kd

Partition to Organic Carbon ml/g

UNIFORM(11,25)

Naphthalene: Calculated kd

Partition to Organic Carbon ml/g

SINGLE(1288)

Nickel

SINGLE(85.7)

Phenols

UNIFORM(22,27)

Fraction of Organic Carbon (fraction)

TRIANGULAR(0.002,0.005,0.019)

Justification for Aquifer Kd Values by Species

NH4 and Cd from site specific testing

Ni, phenol and naphthalene from Consim help files

mecoprop from EA (2004)

Foc from site specific testing

Pathway Density (kg/l):

TRIANGULAR(1.785,1.9402,1.979)

Calculation Settings

Number of iterations: 1001

Results calculated using sampled PDFs

Maximum Head Calculation

Clay Liner:

Retarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

Biodegradation

Saturated Vertical Pathway:

No Vertical Pathway

Aquifer Pathway:

Retarded values used for simulation

Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Ammoniacal_N	Non-Volatile
c (kg/l): 0.59	m (kg/l): 0
Cadmium	Non-Volatile
c (kg/l): 0.1589	m (kg/l): 0.0823
Chloride	Non-Volatile
c (kg/l): 0.2919	m (kg/l): 0.0298
Mecoprop	Non-Volatile
c (kg/l): 0.57	m (kg/l): 0
Naphthalene	Volatile
Half life (years): 10	
Nickel	Non-Volatile
c (kg/l): -0.1479	m (kg/l): 0.0987
Phenols	Volatile
Half life (years): 10	

Contaminant Half-lives (years)

Unsaturated Pathway:

Ammoniacal_N	SINGLE(1e+009)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	SINGLE(1e+009)
Naphthalene	SINGLE(1e+009)
Nickel	SINGLE(1e+009)
Phenols	SINGLE(1e+009)

Aquifer Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	SINGLE(1e+009)

Background Concentrations of Contaminants

Justification for Contaminant Properties

No background concentrations used.

Naphthalene and mecoprop half lifes from Howard et al (1991)

Phenol half life from Consim help files

Mecoprop half life from EA (2003)

All units in milligrams per litre

Phase: Cell 15**Infiltration Information**

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(30,3)
Infiltration to grassland (mm/year):	NORMAL(268.1,26.8)
End of filling (years from start of waste deposit):	1
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Cap infiltration for a membrane cap

Grassland infiltration calculated using Grindley method

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	64
Cell length (m):	197
Cell top area (ha):	1.728
Cell base area (ha):	1.2608
Number of cells:	1
Total base area (ha):	1.2608
Total top area (ha):	1.728
Head of Leachate when surface water breakout occurs (m)	SINGLE(6)
Waste porosity (fraction)	UNIFORM(0.49,0.52)
Final waste thickness (m):	UNIFORM(6,12)
Field capacity (fraction):	UNIFORM(0.4,0.43)
Waste density (kg/l)	UNIFORM(0.39,0.49)

Justification for Landfill Geometry

Geometry based on site plans for each cell

Thickness calculated from restoration contours and basal elevations

Field capacity, porosity and density from Powrie and Beaven (1995)

Source concentrations of contaminants*All units in milligrams per litre*

Declining source term

Ammoniacal_N

LOGTRIANGULAR(4.37,723,3640)

Data are spot measurements of Leachate Quality

Cadmium

LOGTRIANGULAR(0.0019,0.0101,0.105)

Substance to be treated as List 1

Chloride

LOGTRIANGULAR(36.6,2270,7760)

Data are spot measurements of Leachate Quality

Mecoprop

LOGTRIANGULAR(0.000253,0.011,0.067)

Substance to be treated as List 1

Naphthalene

LOGTRIANGULAR(0.0001,0.00046,0.011)

Substance to be treated as List 1

Nickel

LOGTRIANGULAR(0.00883,0.12,2.21)

Data are spot measurements of Leachate Quality

Phenols

LOGTRIANGULAR(0.00025,0.012,0.07)

Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate

NH₄, Cl, Cd, Ni and phenol based on site specific leachate quality

Naphthalene and mecoprop from Knox (2000)

Drainage Information

Type of drainage: Piped

Calculate flow from given parameters:-

Sump radius (m):

0.45

Slope to sump:

1 on 75 (0.76°)

Pipe slope to spine:

1 on 100 (0.57°)

Justification for Ground Slope to Drainage Pipes

Unjustified value

Method of laying pipes:

flat

Diameter of pipes (mm):

150

Spacing of pipes (m):

35

Failure rate of pipes (fraction):

0.2

Justification for Piping Arrangement

Unjustified value

Drainage thickness (m):

0.5

Blanket drain conductivity (m/s):

LOGUNIFORM(0.0001,0.001)

Justification for Drainage Blanket (Piped)

Unjustified value

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
engineered base

Liner installed under CQA

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	TRIANGULAR(1.667,1.793,1.934)
Pathway moisture content (fraction):	UNIFORM(0.302,0.311)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):

Pin holes:	Minimum 0, Maximum 25
Holes:	Minimum 0, Maximum 5
Tears:	Minimum 0, Most Likely 0.1, Maximum 2

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner

Design thickness and site specific testing
Defects are Landsim default

Hydraulic conductivity of mineral lower liner (m/s):	LOGTRIANGULAR(3e-010,4.35e-010,4.35e-010)
--	---

Justification for Composite: Clay or BES Substrate Properties
Conductivity based on site specific testing

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):

Ammoniacal_N	TRIANGULAR(0.125,0.883,2.4)
Cadmium	TRIANGULAR(127,11147,16657)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Fraction of Organic Carbon (fraction)	UNIFORM(0.001,0.004)

Justification for Liner Kd Values by Species

NH4 and Cd from site specific testing

Ni, phenol and naphthalene from Consim help files

mecoprop from EA (2004)

Foc from site specific testing

Shale pathway parameters*Modelled as unsaturated pathway*

Pathway length (m):	UNIFORM(0.5,2)
Flow Model:	porous medium
Pathway moisture content (fraction):	TRIANGULAR(0.213,0.236,0.292)
Pathway Density (kg/l):	TRIANGULAR(1.785,1.9402,1.979)

Justification for Unsat Zone Geometry

Thickness based on basal levels and groundwater levels

Moisture content and density from site specific testing

Pathway hydraulic conductivity values (m/s):	UNIFORM(2.2e-008,4.1e-005)
--	----------------------------

Justification for Unsat Zone Hydraulics Properties

Falling head test data from within shales

Pathway longitudinal dispersivity (m):	UNIFORM(0.05,0.2)
--	-------------------

Justification for Unsat Zone Dispersion Properties

10% of unsaturated zone thickness

Retardation parameters for Shale pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Ammoniacal_N

LOGUNIFORM(0.02647,0.6929)

Cadmium

TRIANGULAR(694,3927,3927)

Chloride

SINGLE(0)

Mecoprop: Calculated kd

Partition to Organic Carbon ml/g

UNIFORM(11,25)

Naphthalene: Calculated kd

Partition to Organic Carbon ml/g

SINGLE(1288)

Nickel

SINGLE(85.7)

Phenols: Calculated kd

Partition to Organic Carbon ml/g

UNIFORM(22,27)

Fraction of Organic Carbon (fraction)

TRIANGULAR(0.002,0.005,0.019)

Justification for Kd Values by Species

NH4 and Cd from site specific testing

Ni, phenol and naphthalene from Consim help files

mecoprop from EA (2004)

Foc from site specific testing

Aquifer Pathway Dimensions for Phase

Pathway length (m):

UNIFORM(0,200)

Pathway width (m):

SINGLE(125)

pathway parameters

No Vertical Pathway

Shale pathway parameters*Modelled as aquifer pathway.*

Mixing zone (m): SINGLE(5)

Justification for Aquifer Geometry

Assumed thickness over which groundwater will flow beneath the site

Darcy flux (m/s): NORMAL(5.52e-007,5.52e-008)

Pathway porosity (fraction): TRIANGULAR(0.213,0.236,0.292)

Justification for Aquifer Hydraulics Properties

Darcy flux based on upgradient recharge resulting in underflow.

Porosity based on typical values for shales

Pathway longitudinal dispersivity (m): UNIFORM(0.75,33.5)

Pathway transverse dispersivity (m): UNIFORM(0.225,10.05)

Justification for Aquifer Dispersion Details

Longitudinal dispersivity 10% of aquifer pathway

Transverse dispersivity 3% of aquifer pathway

Retardation parameters for Shale pathway

Modelled as aquifer pathway.

Uncertainty in Kd (l/kg):

Ammoniacal_N LOGUNIFORM(0.02647,0.6929)

Cadmium TRIANGULAR(694,3927,3927)

Chloride SINGLE(0)

Mecoprop: Calculated kd

Partition to Organic Carbon ml/g UNIFORM(11,25)

Naphthalene: Calculated kd

Partition to Organic Carbon ml/g SINGLE(1288)

Nickel SINGLE(85.7)

Phenols UNIFORM(22,27)

Fraction of Organic Carbon (fraction) TRIANGULAR(0.002,0.005,0.019)

Justification for Aquifer Kd Values by Species

NH4 and Cd from site specific testing

Ni, phenol and naphthalene from Consim help files

mecoprop from EA (2004)

Foc from site specific testing

Pathway Density (kg/l): TRIANGULAR(1.785,1.9402,1.979)



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REPORT ON

WITHYHEDGE LANDFILL PHASE 2 LEACHATE MANAGEMENT PLAN

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Definition of Version Code:

D. Applied during initial drafting of the report before it has been reviewed.

C. Applied after the report has been reviewed but before it has been approved by the Project Manager.

B. Applied after the Project Manager has approved the report ready for issue to the client.

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1.0 INTRODUCTION

1.1 Terms of Reference

Resources Management U.K. Limited (RML) has requested that Golder Associates (UK) Ltd (Golder) address Reference 3 of Table S1.3 Improvement Programme Requirements of the PPC Permit BP3131SG for Withyhedge Landfill Phase 2 (the Site).

1.2 Background

Reference 3 of Table S1.3 of the Permit requires the production of a Leachate Management Plan for the Site. The requirement states:

“The operator shall submit to the Environment Agency a leachate management plan which shall include, but not be limited to the following issues:

- *Volume of leachate to be recirculated including assessment of the potential impact of such activity to ground and surface waters and the generation of odours;*
- *Evidence that any proposed recirculation system is designed to minimise air ingress in to the landfill;*
- *Rainfall and other meteorological data;*
- *Volume of leachate to be removed;*
- *Volume to be disposed off-Site;*
- *Details of the extraction plan;*
- *Any pre-treatment of leachate prior to disposal and/or recirculation;*
- *Any additional abstraction and storage infrastructure required;and*
- *Integrity testing of leachate storage infrastructure.*

The extraction plan shall include:

- *A plan showing the spatial distribution of extraction points;*
- *Consideration of the zone of influence of each well;*
- *Full well design and specification;*
- *Proposed pumping regime including written justification;and*
- *Contingency action plan.*

The operator shall implement any measures as agreed in writing by the Environment Agency.”

Golder has prepared the following report in accordance with the requirements of Table S1.3.

1.3 Objectives

The objectives of this work are to provide the Environment Agency with a document that presents a water balance for the Site, a leachate management plan including information regarding extraction, storage and disposal of leachate, and details of the monitoring regime.

1.4 Report Structure

Details of the existing site situation are presented in Section 2.0. The water balance for the Site is presented in Section 3.0, and presents all of the water inputs, outputs and storage characteristics of the Site presented in a water balance spreadsheet model. Section 4.0 presents details of the proposed leachate management, including well location and design, and plans for storage and disposal of leachate. Section 5.0 presents the leachate monitoring regime along with a contingency action plan in the event of elevated leachate levels. Section 6.0 presents the summary and recommendations from the report.

2.0 EXISTING SITE SITUATION

The Site is located approximately 5.5 km north of Haverfordwest in Pembrokeshire at National Grid Reference SM 970 217. It is bounded to the north and west by Rudbaxton Water, to the east by the existing Phase 1 landfill and to the south by agricultural land.

The Site is classified as a non-hazardous landfill, accepting commercial and industrial waste similar in type and quantity to that previously accepted at the neighbouring Withyhedge Phase 1 Landfill. It is currently envisaged that between 80,000 tonnes and 115,000 tonnes of waste will be deposited at the Site each year.

The layout of the Site and the phasing of waste deposition are presented in Drawing LMP1. The layout of subsequent cells will be designed based on the results of further investigation and annual waste inputs.

Drift and shale will be removed from the Site as each cell is constructed. Clays will be stockpiled to be used as engineered lining systems. Other material will be retained for daily cover, inert fill and capping soils. Depth of extraction will be limited to leave a 1 m thick unsaturated zone to attenuate leakage from the basal lining system.

3.0 SITE WATER BALANCE

3.1 Introduction

A water balance calculation has been undertaken to consider the potential for generation of excess leachate at the Site (the volume requiring removal) and therefore whether the capacity of the leachate storage and disposal system is sufficient.

This water balance aims to compare the quantities of water entering and leaving the waste during specified time periods. Any imbalance between water input and water output will lead to a change in the quantity of liquid held in the waste as leachate.

Water is present in the landfill either as free leachate or absorbed onto or into solid waste materials. The amount held in each form depends on the storage characteristics of the waste. This varies depending on the type, source and age of the waste.

The water balance calculations are based on the standard water balance equation for any hydrologic system, where the rate of inflow minus the rate of outflow is equal to the rate of change of the quantity of water stored within the system. In its application to a landfill system, this equation is rearranged and combined with assumptions about the volume and storage characteristics of the waste. The volume of free leachate in a specified time period can be calculated using the following equation:

$$V_L = V_{(in)} - V_{(out)} - AW$$

Where

- V_L Volume of free leachate in the landfill system (m^3)
- $V_{(in)}$ Volume of water entering the landfill system (m^3)
- $V_{(out)}$ Volume of water leaving the landfill system (m^3)
- A Absorptive capacity of the waste ($m^3/tonne$)
- W Waste input during the specified time period (tonne)

Water may enter the landfill as a result of effective rainfall, surface run-on, groundwater discharge, and leachate recirculation. Water can leave the landfill by evaporation, transpiration, surface run-off, surface seepage or springs, groundwater recharge, and leachate removal.

3.2 Components of the Water Balance

3.2.1 Effective Rainfall

Effective rainfall is commonly the major input to the water balance. It is defined as the amount of rainfall available for infiltration after run-off and evapotranspiration losses have been taken into account and any soil moisture deficit has been satisfied. A soil moisture deficit evolves as a result of an excess of evapotranspiration over rainfall.

In accordance with the hydrogeological risk assessment (Reference 1), an infiltration to open waste of 338 mm per year is assumed. This has been calculated using data from met office records for Aberpoth (Reference 2) and the Grindley method.

The effective rainfall through any temporarily capped areas of the Site is estimated to be 150 mm per year. Based on the proposed permanent cap specification for the Site (LLDPE geomembrane), the effective rainfall infiltrating the waste is assumed to be 30 mm per year for permanently restored phases, in accordance with the hydrogeological risk assessment.

3.2.2 Surface Water Run-Off

Surface water management for Phase 2 will comprise surface water collection ditches around the perimeter of the Site and two surface water collection lagoons located on the western site boundary. These lagoons will discharge via points known as D2 and D3 into Rudbaxton Water.

The spring to the south of the Site that currently flows through the Phase 2 area will be diverted along the southern boundary of the Site to the lagoon to the west of the installation boundary.

The final restoration profile will be sufficiently steep so as to encourage run-off. Surface water run-on is therefore not included in the inputs and surface water run-off is not included in the outputs.

3.2.3 Groundwater Inflow

Withyhedge Phase 2 Landfill is engineered to ensure that a 1 m unsaturated zone remains beneath the Site. Groundwater inflow to the waste is therefore assumed to be negligible and will not contribute to leachate production.

3.2.4 Storage Characteristics

As water percolates down through the Site, it may be absorbed by the porous components of the waste. Waste at field capacity is defined as the maximum amount of moisture that can be held by the waste against the pull of gravity. The absorptive capacity is defined as the maximum amount of water that can be taken up by the waste to take it from its initial moisture content to field capacity.

Estimates of absorptive capacity of refuse vary widely between authors, ranging from 0.02 m³/tonne (Reference 3) to 0.24 m³/tonne (Reference 4). Based on the findings of the literature review, a conservative value of 0.02 m³/tonne has been adopted for the water balance. It should be noted, however, that this value might underestimate the absorptive capacity of the waste that is deposited at the Site.

Where free leachate is present across the base of the Site, waste is saturated. The difference between the volume of water retained at field capacity, and that present at saturation is known as the drainable porosity. This has been used to estimate the available leachate storage resulting from saturation of the waste to the leachate compliance level (1 m above the base of the cell). A drainable porosity of 6.5% by volume has been assumed based upon work by Powrie and Beaven (Reference 5). A leachate storage volume in each cell as a result of waste saturation has been estimated by applying this to a saturated volume equal to the basal cell area multiplied by the leachate head.

3.3 Water Balance Methodology

The water balance calculation has been undertaken using an Excel spreadsheet. Results and one example of the calculations spreadsheet for Area A Cell 1 (North) and Cell 2 (North) is presented in Appendix LMP1. For each year, the spreadsheet calculates the volume of leachate being produced within each cell of the landfill by subtracting the volume of infiltrating water taken up by the absorptive capacity of the waste from the volume of water entering the phase. Any absorptive capacity remaining at the end of each period is carried over to the next period and the calculations are carried out again.

The PPC Permit for the Site requires leachate levels to be below the compliance level of 1 m above the base of the cell. The permitted volume of leachate is calculated for each cell based upon the basal area and the drainable porosity. Any leachate volumes in excess of this permitted volume are calculated from the leachate volume generated. It is assumed that the full excess volume is removed each year and any leachate volumes at or below the permitted volume are carried over to the next year.

It is predicted that between 80,000 and 115,000 tonnes of waste will be deposited at the Site per annum. For the purpose of the water balance the maximum waste input of 115,000 tonnes has been assumed.

Re-circulation of leachate at the Site has not been included within the water balance with the assumption made that any volumes removed from a cell will be re-circulated back to the same cell.

3.4 Summary of Results

3.4.1.1 Absorptive Capacity

The water balance has been used to assess the amount of absorptive capacity that is contained within the current landfill cell and how long the absorptive capacity in the new cells will be available. The additional absorptive capacity from waste input is found to be much smaller than the volume of water entering the landfill each year and therefore in every cell no residual absorptive capacity remains from one year until the next.

3.4.1.2 Future Abstraction Requirements

The water balance has been used to predict the abstraction requirements to ensure that leachate levels are within the trigger levels. The water balance predicts that the periods when the greatest volumes of leachate will be required to be removed are whilst the cells are operational. The total leachate abstraction requirements for each year predicted are presented in Table LMP1.

Table LMP1: Leachate Abstraction Requirements

Year	Leachate Volume (m ³ /yr)	Leachate Volume (m ³ /week)
2007	3683	71
2008	5980	115
2009	5668	109
2010	5382	104
2011	3972	76
2012	3547	68
2013	3808	73
2014	4069	78
2015	4330	83
2016	4591	88
2017	4852	93
2018	5979	115
2019	6705	129
2020	7059	136
2021	7413	143
2022	7767	149
2023	8121	156
2024	8475	163
2025	8829	170
2026	8190	158
2027	7263	140
2028	7458	143
2029	7653	147
2030	7848	151

Year	Leachate Volume (m³/yr)	Leachate Volume (m³/week)
2031	8043	155
2032	9476	182
2033	11088	213
2034	11469	221
2035	11850	228
2036	12231	235
2037	12612	243
2038	11754	226
2039 onwards	10230	197

The water balance predicts that a short-term rate of around approximately 87 m³/week (12.4 m³/day) will be required in the next 10 years to maintain compliant leachate levels. Over the lifetime of the Site the maximum volume of leachate requiring removal is predicted to be approximately 243 m³ per week (34.7 m³ per day). When the entire site is permanently capped in the long term, extraction rates of approximately 200 m³/week (28.6 m³/day) will be required.

It should be noted that volumes estimated in the water balance are based upon a constant infiltration rate across the Site. In reality, infiltration will vary seasonally due to rainfall and therefore it is likely that leachate generation will increase during winter months. The leachate volume per week is therefore an average required extraction volume and may increase and decrease on a seasonal basis.

4.0 LEACHATE MANAGEMENT

4.1 Leachate Extraction Plan

Leachate will be extracted from the cells to maintain the level of leachate within each cell no greater than 1 m above the base of the cell. The following sections provide details of the location, structure and pumping regime for the leachate extraction system.

4.1.1 Basal Collection System

The leachate drainage system will comprise a gravel drainage blanket in accordance with the Environment Agency's recent guidance (Reference 6). The base of each cell will be profiled to provide a minimum fall of 1:50 towards a leachate collection sump. A pipe system will be placed on the surface of the basal lining system that comprises a central 150 mm internal diameter HDPE slotted pipe with secondary drains comprising 100 mm internal diameter HDPE slotted pipe connected at 50 m intervals in a herringbone pattern as shown on Drawing LMP1. The central pipe will be connected to the leachate collection sump, which will be constructed from the base of the cell to the surface of the Site to enable the extraction of the collected leachate.

All leachate pipework will be delivered, handled, and stored in accordance with the manufacturer's recommendations and in such a way that damage will not occur to any material. The pipes will be stored in an area flat enough to accommodate the entire length of the pipes and in such a way so that they are not deformed or damaged. The pipes will not be stacked higher than 1 m.

Confirmation of the quality control procedures taken by the pipe manufacturer and copies of quality control certificates will be provided to RML. A record of the materials used in construction of the leachate collection system, manufacturer's quality control certificates and as-built drawings shall be submitted as part of the CQA reporting on the cell construction.

4.1.2 Zone of Influence of Leachate Well

The presence of a leachate drainage blanket at the base of the landfill enables the zone of influence of the leachate extraction wells to span the entire cell.

Should the blanket be able to maintain a leachate level below the compliance level of 1 m across the Site it is considered that the zone of influence will be adequate.

The performance of the leachate drainage system installed in Area A has been assessed using LandSim v2.5 to determine the maximum likely leachate head and therefore the likely zone of influence of the leachate extraction wells. Areas B to E are to have drainage blankets of the same construction.

Model *leachatedrainage.sim* has been run to simulate the drainage system using the input parameters described in Section 4.1.1. A hard copy of the model is included in Appendix LMP2.

Table LMP2: Predicted Maximum Leachate Head

Maximum Leachate Head (m)	
50 th percentile	95 th percentile
0.15	0.33

The model results show that at the 95th percentile leachate levels can be maintained well below 1 m above the base of the cell and therefore the extraction system is considered to provide a sufficient zone of influence within the Site.

4.1.3 Location

Schedule 2 of the Landfill (England and Wales) Regulations 2002 states that where the collection of leachate is necessary then the leachate collection system should ensure that leachate accumulation at the base of the landfill is kept to a minimum, and at least within the compliance levels. The minimum requirement is therefore one abstraction point for leachate per hydraulically isolated cell. The information given in the Hydrogeological Risk Assessment suggests that all the current cells are hydraulically isolated. Therefore, a minimum of one abstraction point will be located within each cell.

The proposed location of leachate sumps within Area A Cells 1 to 3 are shown on Drawing LMP 1. The layout of Areas B to E will be designed as each area is developed.

4.1.4 Well Design

4.1.4.1 Leachate Well Bases

The bases for the leachate monitoring wells will be a 2000 x 2000 x 300 mm reinforced concrete pad. The finished level of the concrete base shall be the same as that of the top of the lining system. In addition, a target pad will be constructed adjacent to the base for potential redrilling of the chamber if deemed necessary.

The target pad will be 3000x3000x300 mm reinforced concrete. Reinforcement will comprise two layers of A193 mesh with a minimum cover of 50 mm.

Beneath both slabs, the clay liner will be locally thickened to maintain the 1 m thickness. The geomembrane liner shall also pass beneath the slab and be protected by a double layer of protection geotextile as shown on Drawing LMP2.

4.1.4.2 Leachate Monitoring Well

The wells shall be constructed using 900 mm internal diameter twin walled HDPE pipe extending to the surface of the landfill. The bottom 2 m of the well shall be perforated to allow the ingress of leachate into the chamber. The remainder of the pipework shall be solid. The top of the chambers shall be completed with suitable temporary cover to allow the wells to be extended by RML as waste placement progresses. In areas where the sumps are adjacent to the perimeter slopes, 300 mm HDPE upslope risers will be used for the purposes of leachate removal.

Additional gravel shall be placed to 2 m above the top of the slab level around the perforated section of the base unit as shown on Drawing LMP2.

4.1.5 **Leachate Extraction Regime**

Currently, leachate is extracted from the leachate well located at the north end of Cell 1 by means of a tractor and vacuum tanker with a nominal capacity of 2800 gallons. The tractor removes the leachate from the sump under vacuum and then transports the load to the storage tank where the leachate is then blown under pressure into the tank. Currently, 1 load per day (12.73 m^3) is typically extracted from Cell 1. This is currently found to be adequate to sustain leachate levels below 1 m above the base of the cell. However this frequency may increase should there be a prolonged period of inclement weather.

At present no plans to change the method of leachate extraction have been made. However, it is acknowledged by RML that once more cells become active and more leachate is, installation of submersible pumps and associated pipe work may be required. This will be reviewed on an annual basis and prior to development of any new cells and any appropriate changes implemented where necessary.

The water balance for the Site presented in Section 3.4 shows that the current disposal rate of approximately 12.7 m^3 per day (1 tanker load) will be adequate to control leachate levels for the next 10 years, after which time it is predicted that leachate production will be such that the required amount for disposal will exceed 12.7 m^3 per day (90 m^3 per week). The predicted leachate volumes requiring removal are presented in Table LMP1.

4.2 **Leachate Storage**

Leachate is to be stored prior to disposal in a leachate storage tank located to the east of Phase 1. Leachate from both Phases 1 and 2 can be stored within this same tank. The leachate storage tank is a 23,000 gallon (105 m^3) capacity steel tank, on an engineered clay base and surrounded on three sides by an engineered clay bund. The clay base falls towards the bunded end and has a capacity of approximately 50,000 gallons. All filler pipes, vents, outlet pipes are kept within the bunded area.

Leachate will be pumped from the Site by vacuum tanker and leachate will then be transferred into the holding tank by pumping directly from the vacuum tanker. Any build up of rainfall within the bund is removed by vacuum as and when required.

The tank will be inspected at weekly intervals and prior to transfer of leachate. If the tank is found to be damaged such that a leak may occur, or is leaking, then arrangements will be made immediately to have the tank repaired. If the tank is found to be leaking following commencement of leachate transfer, then the leachate transfer will cease pending repair of the tank.

The tank bund and clay base will be inspected at weekly intervals and prior to leachate transfer. If the bund or base is found to be damaged such that a leak may occur, then arrangements will be made immediately to have the bund or base repaired. If the bund is found to be leaking, then immediate measures shall be taken to have the bund emptied to minimise further leakage and appropriate measures shall be taken to clear any contamination of ground outside the tank bund. This may include, use of absorbent materials to contain and absorb spillages, or excavation of contaminated ground and disposal as appropriate. Used absorbent material will be excavated and transferred to containers for disposal at an appropriate facility. Where both the tank and the bund are found to be leaking, then immediate arrangements will be made to have the leachate tank contents emptied into other containers or tanks.

Details of the weekly inspections of tanks, bunding and repairs, or remedial measures taken in event of spillage will be recorded in the Site diary.

Volumes of leachate extracted from Phase 1 between March 2006 and February 2007 have been between 212,000 and 614,000 gallons per month (32 m³ to 93 m³ per day). With the additional leachate extracted from Phase 2 (currently 12.7 m³ per day), the water balance suggests that the leachate storage tank has sufficient capacity in the short term providing tankering off-Site occurs daily. However, with increase of leachate production in Phase 2 alone, a larger capacity storage tank will be required within the next 10 years. The capacity for leachate storage should be reviewed on an annual basis.

4.3 Leachate Disposal

The leachate that will be generated at the Site is expected to have a quality similar to that currently being produced in the Withyhedge Phase 1 Landfill. Leachate will be removed from the leachate collection sumps and will be temporarily stored in the above ground storage tank. It will be tankered from site for off-Site treatment and disposal at an appropriate facility.

4.4 Leachate Recirculation

During waste infilling, when required, leachate may be re-circulated back into the waste mass in individual cells. Excess leachate extracted from the basal drainage systems in these cells will be re-circulated within unsaturated wastes and will assist in the promotion of accelerated stabilisation of the wastes by maintaining moisture levels within the waste body as a whole and assist in the flushing out of contaminants such as ammoniacal nitrogen. This process will also aid landfill gas production, and the use of active landfill gas extraction and flaring will aid biodegradation. Enhanced gas production rates resulting from leachate re-circulation and gas extraction will further promote accelerated stabilisation. Re-circulation also provides a means of leachate level control in the Site.

Leachate will be re-circulated after collection in the extraction wells onto the waste mass in the active cell by pumping below the surface using temporary pipework or a vacuum tanker into recently placed wastes via trenches excavated to a depth of 0.5 m deep by 0.5 m wide by 100 m length. Perforated pipework will be installed in the excavated trenches and these will then be backfilled with general wastes. A vacuum tanker will be used where pipework on the surface may interfere with site operations.

Once waste reaches final levels, a sub-cap irrigation system will be installed, comprising pipework to a similar specification as the herringbone drainage system, placed in 0.5 m deep by 0.5 m wide trenches excavated into the waste at the surface of the landfill. Trenches will be backfilled with selected hardcore and aggregate which is free draining. A similar layout to the herringbone placed in the base will be used to obtain coverage of the Site surface and therefore to develop a sufficient wetting area as it percolates downwards through the waste, such that a uniform distribution of moisture content may be achieved.

To assist in the recirculation process, potential barriers to the uniform distribution of leachate within the waste mass will be minimised. Low permeability cover materials will not be used as daily cover. Where such materials are used as daily or intermediate cover, these will be removed prior to deposit of subsequent lifts of waste.

In order to prevent waste slope instability, leachate recirculation should not be carried out within 30 m of any waste slope. However, if leachate recirculation cannot be controlled, then the maximum waste slope should not exceed 1v:2.5h (Reference 7).

To minimise odour from these operations, leachate will not be spray irrigated onto areas of the Site, and shallow trenches (once backfilled with hardcore) will be covered over with suitable material to suppress odour from the re-circulation trench. Pipework will be introduced into these trenches before leachate is pumped in, and the discharge will be monitored to ensure that it does not give rise to unacceptable odour.

Should unacceptable odour arise, or the trench become saturated, the discharge will be discontinued and moved to an alternative discharge point. Where trenches become a source of odour, these will be abandoned and the entry covered over to prevent further odour. The use of trenches will be rotated to obtain a uniform distribution of wetting and prevent saturation at individual locations.

4.5 Leachate Pre-Treatment

The Hydrogeological Risk Assessment (Reference 1) has concluded that leachate strength will still be too high after the 60 year management period and will still need to be managed if leachate remains as concentrated as predicted. It may therefore be necessary to try and reduce leachate strength in the long term, by pre-treatment prior to re-circulation.

However, at present given that Phase 2 is in the very early stages of waste disposal, leachate production volumes are not constant enough that pre-treatment would be economically or technically feasible. Once the Site is further developed and larger volumes of leachate are produced all year around, pre-treatment may be considered. Re-circulation will provide some flushing of contaminants in the short term, which will help to reduce leachate strength.

A potential future method for pre-treatment has not yet been identified as it is considered that the best available technique at the time of implementation would be most appropriate.

4.6 Inspection and Maintenance

Maintenance of the pre-engineered leachate containment, collection and monitoring systems should be a priority at the Site. The most valuable asset at a site for the control of leachate is a fully functioning engineered leachate management infrastructure. At Withyhedge this consists of the basal leachate drainage and collection system, leachate extraction and monitoring wells, and the leachate storage tank. In addition to the vertical leachate extraction wells, one upslope riser pipe will be installed around the perimeter of each cell. These upslope risers will be of the same diameter, and will be connected to, the main leachate spine drains. The upslope risers will form a back-up to the vertical extraction and monitoring wells and may be used for CCTV inspection and jetting.

Full historic CQA documentation of these elements will be maintained. Further records will be maintained of the construction details of any future retro-fitted leachate pumping and monitoring structures to include as a minimum the location, construction details, basal level, and top datum.

When any failures in the leachate collection infrastructure are found these should be remediated as quickly as possible. The most common form of failure is blockage or collapse of leachate pumping or monitoring structures.

Inspection and maintenance activities include the following actions:-

- Inspection of drainage blanket and collection pipework during placement of the initial lift of waste in the base of each cell, to ensure that any damage is identified and remedial action taken;
- Weekly inspection of leachate chambers for evidence of damage and the repair of damaged items to ensure that the integrity of the system is maintained;
- Review and assessment of leachate extraction and monitoring riser pipes to assess suitability for use, and retro-drilling of pipes where excessive deflections or blockages occur; and
- Inspection and remedial measures (e.g. jetting or use of a ‘guzzler’) to extraction pipework, when necessary, to maintain the ability to reduce leachate levels.

5.0 LEACHATE MONITORING

5.1 Monitoring Infrastructure

A minimum of two leachate monitoring points per cell will be installed to allow monitoring of leachate levels remote to the leachate abstraction point. The locations of leachate monitoring wells are shown on Drawing LMP1.

Locations which will be used for leachate monitoring and sampling are given in Table LMP3:

Table LMP3: Leachate Monitoring Locations

Cell	Leachate Extraction Well	Leachate Monitoring Well
Area A Cell 1 North	L1	LM1
Area A Cell 2 North	L2	LM2
Area A Cell 3 North	L3	LM3
Area A Cell 1 South	L4	LM4
Area A Cell 2 South	L5	LM5
Area A Cell 3 South	L6	LM6
Area B onwards	To be advised	To be advised

5.2 Leachate Levels

5.2.1 Compliance Level

In accordance with the findings of the Hydrogeological Risk Assessment, the leachate level within each cell will be maintained at or below 1 m above the base of the cell.

5.2.2 Monitoring Schedule

Following installation the leachate points specified above will be monitored at weekly intervals and leachate levels measured, accurate to +0.01 m, determined relative to Ordnance Datum, and as leachate head above base. Once each cell is capped, the level of leachate in the boreholes will be monitored on a monthly basis. Results of leachate level measurements will be forwarded to the Environment Agency on a quarterly basis.

5.2.3 Contingency Action Plan

Given the identified risk of overtopping at the Site and the sensitivity of the adjoining SAC, as outlined in the Hydrogeological Risk Assessment, a contingency action plan has been developed in order to ensure that risk to surrounding groundwater and surface water is not posed should compliance levels be breached.

The proposed action plan following breach of the compliance level is presented in Table LMP4.

Table LMP4: Proposed Action Plan following Breach of a Trigger Level

1.	Generate internal incident report to assess potential breach.
2.	Report to Environment Agency in accordance with the permit.
3.	Check that the leachate extraction system is operational and increase monitoring of leachate level to daily. Daily monitoring in the leachate level monitoring point will continue until levels have been reduced. Site management will inspect the Site on a daily basis to ensure that no evidence of leachate breakout is observed.
4.	If initial repeat measurement confirms breach of the compliance level, review site management and operations and commence increased pumping in the relevant leachate extraction points. Cease any re-recirculation into the affected cell. Consider re-circulation of leachate from the affected cell into other compliant cells.
5.	If the leachate level cannot be reduced within 7 days of pumping, then discussions will be held with the Agency, and proposals submitted within 14 days for the reduction of leachate in the phase to comply with compliance levels, and will be implemented following approval of the Agency.
6.	If continued breaches occur, review existing hydrogeological risk assessment.
8.	If risks are unacceptable, set in place procedures for implementing permanent corrective measures in consultation with, or required by, the Agency.

5.3 Leachate Quality

5.3.1 Action Levels

Leachate quality will be assessed with regard to the following action levels presented in Table LMP5 to ensure that leachate strength does not deteriorate and pose a risk to the surrounding surface and groundwater environment.

Table LMP5: Action Levels for Leachate Monitoring

Cell	Ammoniacal Nitrogen (mg/l)	Chloride (mg/l)	Cadmium (mg/l)	Mecoprop (mg/l)	Naphthalene (mg/l)	Nickel (mg/l)	Phenol (mg/l)
Area A Cells 1 (North) and 2 (North)	3,840	7,760	0.105	0.016*	0.042	2.21	12
Remainder of Phase 2	3,840	7,760	0.105	0.14	0.042	2.21	12

Values taken from Table S4R6 of schedule four response (Reference 8).

** Action level for mecoprop proposed in permit variation application.*

5.3.2 Monitoring Schedule

Leachate will be sampled from one monitoring point in each of the cells once waste has been deposited in the relevant cell and analysed as detailed in Table LMP6.

Table LMP6: Leachate Monitoring Frequency and Analytical Determinands

Parameter	Landfilling Phase		Closure/Aftercare Phase	
	Quarterly	Annually	Six Monthly	Annually
pH	•+	•+	•+	•+
Temperature	•*	•*	•*	•*
Electrical conductivity 20°C	•+	•+	•+	•+
Ammoniacal nitrogen	•	•	•	•
Chloride	•	•	•	•
Sulphate	•	•	•	•
Alkalinity	•	•	•	•
COD	•	•	•	•
BOD	•	•	•	•
Nitrate (for TON)	•	•	•	•
Nitrite (for TON)	•	•	•	•
TOC	•	•	•	•
Sodium	•	•	•	•
Potassium	•	•	•	•
Calcium	•	•	•	•
Magnesium	•	•	•	•
Iron		•		•
Manganese		•		•
Ionic balance		•		•
List I/ II substances		•		

Key : + denotes field or laboratory measurements (subject to availability of field equipment, samples may be sent for laboratory analysis instead)
* denotes field only measurements

Analysis, detection limits and reporting of results will be undertaken in accordance with guidance issued by the Agency.

5.3.3 Contingency Action Plan

Action plans have been developed in the event that a leachate action level is breached. Table LMP7 presents the action plan in the event of a breach in chloride, ammoniacal nitrogen, cadmium, naphthalene, nickel, phenol and mecoprop for the whole of Phase 2 with the exception of Area A Cell 1 (North) and Cell 2 (North).

Table LMP7: Proposed Action Plan following Breach of an Action Level

1.	Report to Environment Agency in accordance with the permit.
2.	The sample will be re-tested for the determinant by analytical laboratory within 2 weeks.
3.	Where the action level is breached on two consecutive occasions, or on three or more occasions during a year, an appropriate course of action and timescales will be agreed with the Agency and implemented.
4.	If advised by the Agency, the hydrogeological risk assessment may need to be revised.

A proposed contingency action plan for a breach of the mecoprop action level, as discussed in the permit variation application, is presented in Table LMP8.

Table LMP8: Proposed Action Plan following Breach of an Action Level for Mecoprop in Area A Cell 1 (North) and Cell 2 (North)

Timescale¹	Action
1 day	Advise site management.
1 day	Advise environmental manager of landfill operating company.
2 weeks	Confirm by repeat sampling and analysis.
2 weeks	Advise Environment Agency if second result exceeds the action level.
4 weeks	If second result also exceeds the action level review existing monitoring information.
12 weeks	Submit revised HRA supported by modelling using a leachate source term developed from all the monitoring data received to date. Mitigation measures include the consideration of restricting leachate heads, restricting waste inputs and increased groundwater monitoring in consultation with the Environment Agency.

1 Time from exceedance being reported to RML

6.0 SUMMARY AND RECOMMENDATIONS

The purpose of this report is to address Reference 3 Table S1.3 of the PPC Permit for Withyhedge Landfill Phase 2 by presenting a Leachate Management Plan.

6.1 Leachate Management, Storage and Disposal

A Leachate Management Plan has been developed for Withyhedge Landfill Phase 2. The suitability and sustainability of the proposed method of management has been considered by means of a water balance. The water balance provides estimates of the volume of leachate which will require removal on a cell by cell basis.

The water balance predicts that a short-term rate of around approximately 87 m³/week (12.4 m³/day) will be required in the next 10 years to maintain compliant leachate levels. Over the lifetime of the Site the maximum volume of leachate requiring removal is predicted to be approximately 243 m³ per week (34.7 m³ per day). When the entire Site is permanently capped in the long term, extraction rates of approximately 200 m³/week (28.6 m³/day) will be required.

The water balance has concluded that current leachate production rates can be adequately managed by storage and disposal of leachate via tankering off-Site. Providing leachate removal does not increase in Phase 1 of the landfill and therefore capacity of storage is reduced for Phase 2, the current system should be sustainable for up to 10 years.

A leachate extraction plan has been provided which presents drawings showing the location, full design and specification of extraction points. Discussion regarding the extraction regime and zone of influence of each well has also been presented. Storage and disposal of leachate has also been included in the report.

6.2 Leachate Monitoring

A minimum of two leachate monitoring points per cell will be installed to allow monitoring of leachate levels remote to the leachate abstraction point.

The leachate level within each cell will be maintained at or below 1 m above the base of the cell. A contingency action plan has been developed in order to ensure that risk to surrounding groundwater and surface water is not posed should compliance levels be breached.

Leachate quality is also to be assessed against a series of action levels in order to ensure that leachate strength does not deteriorate and pose a risk to the surrounding surface and groundwater environment. A contingency action plan has been developed in the event that a leachate action level is breached.

6.3 Recommendations

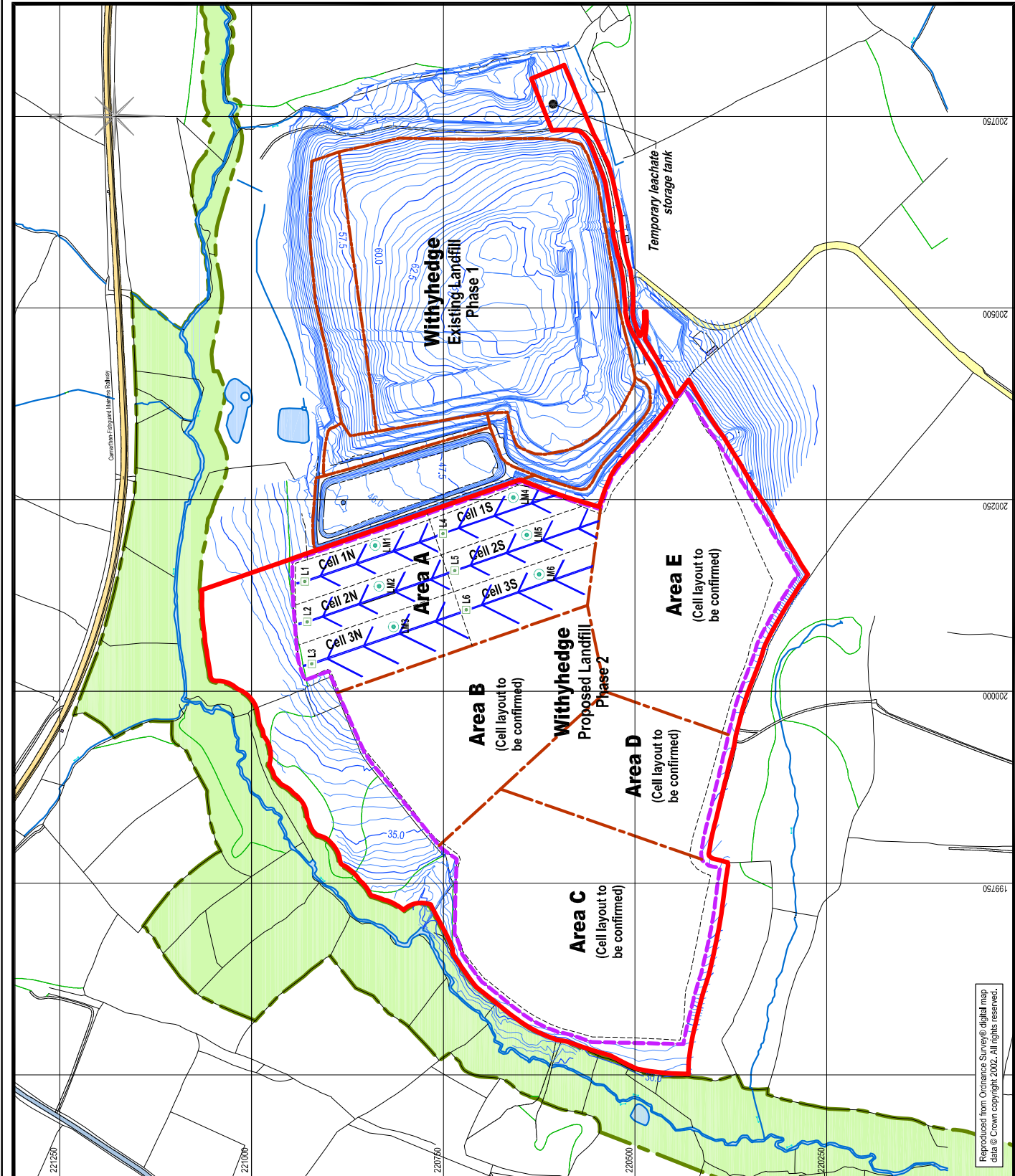
As a Site improvement plan, it is recommended that:

- The requirement for an additional leachate storage tank should be reviewed on an annual basis; and
- The leachate extraction methodology should be reviewed on an annual basis.

7.0 REFERENCES

1. Golder Associates (UK) Limited. (2005). Withyhedge Landfill Phase 2 PPC Permit Application, Hydrogeological Risk Assessment Ref. 04529421.502/A.0, June 2005.
2. www.met-office.gov.uk
3. North West Waste Disposal Officers. (1991). Leachate Management Report, November 1991.
4. Beaven, R.P. and Powrie, W. (1995). Hydrogeological and geotechnical properties of refuse using a large-scale compression cell. Proceedings Sardinia 1995. Fifth International Landfill Symposium
5. Powrie, W. and Beaven, R.P, (1999). Hydraulic Properties of Household Waste and Implications for Landfills. Proceedings of the Institution of Civil Engineering 137, pp 235 – 247.
6. Environment Agency (2007). Recommendations for Aggregate Leachate Drainage Layers, Final, 23 April 2007.
7. Golder Associates (UK) Limited. (2005). Withyhedge Landfill Phase 2 PPC Permit Application, Stability Risk Assessment Ref. 04529421.503/A.0, June 2005.
8. Golder Associates (UK) Limited. (2006). Response to Schedule Four Notice dated 20 December 2005, Withyhedge Landfill Phase 2, Ref. 04529421.518/A.0, January 2006.

DRAWINGS



NOTE

1. The leachate management system for Areas B to E will be confirmed prior to the development of each area.

LEGEND

- Installation boundary
- Limit of waste disposal
- Afonydd Cledau cSAC boundary
- Phase boundary
- 62.5
- Ground level contour (mAOD)
- Break of slope
- Proposed leachate pipework
- Proposed leachate extraction well
- Proposed leachate monitoring well



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Project

Leachate Management Plan

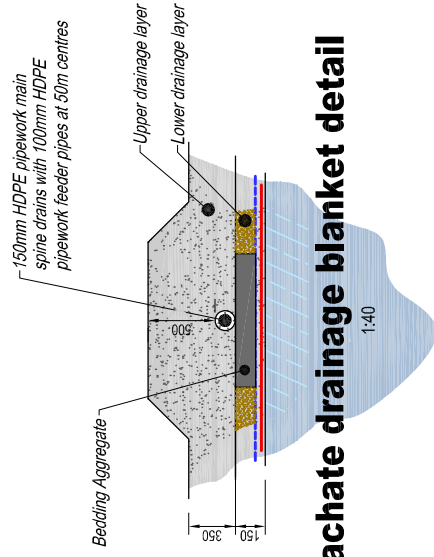
Location
Withyhedge Landfill

Title

Site Layout and Leachate Management

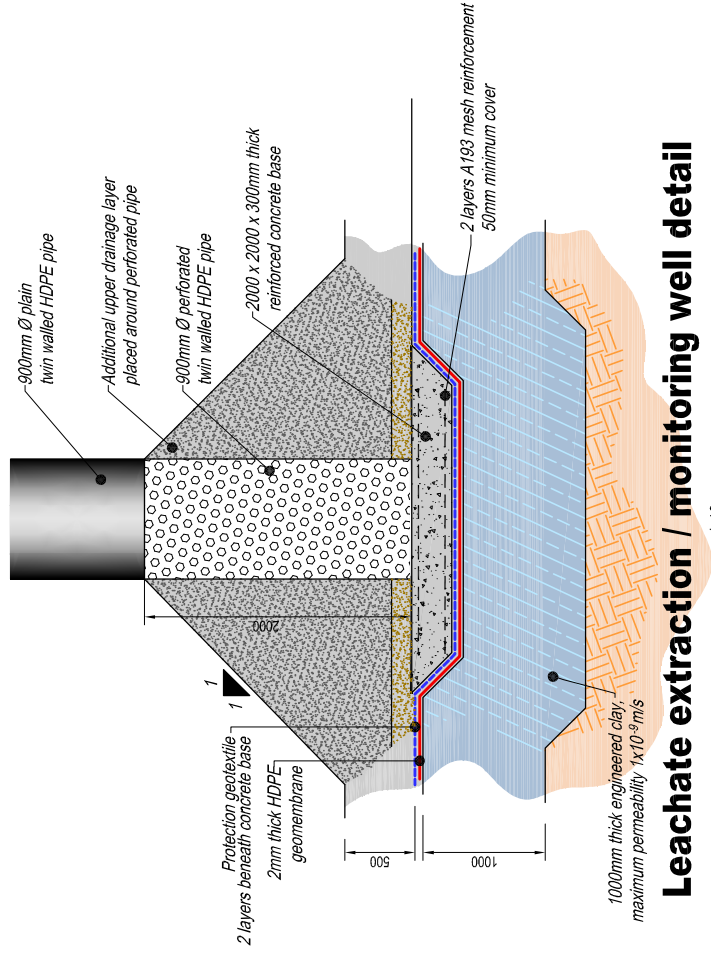
Project No.	06529234	Engineer	NC	Drawing No.	LMP1
File No.	52275421	Reviewed by	DAE		
Created by	A.B.				
Scale	1:5,000 @ A3	Date	31st May 2007		





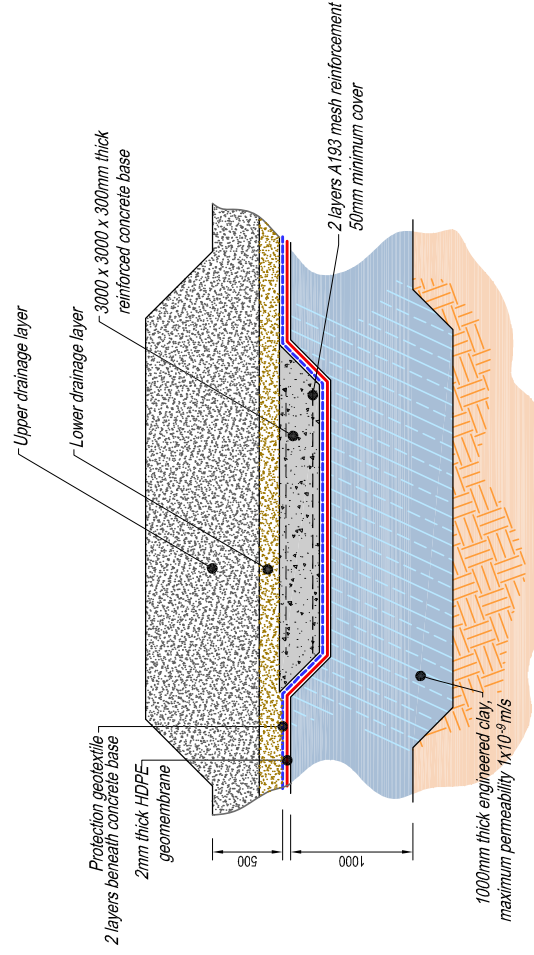
Leachate drainage blanket detail

1:40



Leachate extraction / monitoring well detail

1:40



Target pad detail

1:40



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Leachate Management Plan

Withyhedge Landfill

Leachate Management System Construction

Project No.	06529234	Engineer	NC	Drawing No.	LMP2
File No.	527543	Reviewed by	DAI		
Created by	A.B.				
Scale	As Shown @ A3	Date	31st May 2007		



APPENDICES

APPENDIX LMP1

WATER BALANCE

Withyhedge Landfill Water Balance Summary

Total Site Leachate Volumes Required to be Removed to ensure leachate trigger levels

Year	Leachate Volume (m ³ /yr)	Leachate Volume (m ³ /week)
2007	3683	71
2008	5980	115
2009	5668	109
2010	5382	104
2011	3972	76
2012	3547	68
2013	3808	73
2014	4069	78
2015	4330	83
2016	4591	88
2017	4852	93
2018	5979	115
2019	6705	129
2020	7059	136
2021	7413	143
2022	7767	149
2023	8121	156
2024	8475	163
2025	8829	170
2026	8190	158
2027	7263	140
2028	7458	143
2029	7653	147
2030	7848	151
2031	8043	155
2032	9476	182
2033	11088	213
2034	11469	221
2035	11850	228
2036	12231	235
2037	12612	243
2038	11754	226
2039 onwards	10230	197

Assumed Filling Cycle

Year	Operational Area	Temporarily Capped Cells	Permanently Capped Cells	Total tonnage Input
2007	2A Cell 1+2(N)			1.15E+05
2008	2A Cell 1+2(S)	2A Cell 1+2(N)		1.15E+05
2009	2A Cell 3 (N)	2A Cell 1+2(S)	2A Cell 1+2(N)	1.15E+05
2010	2A Cell 3 (S)	2A Cell 3 (N)	2A Cell 1+2(S)	1.15E+05
2011	2B Cell 1	2A Cell 3 (S)	2A Cell 3 (N)	1.15E+05
2012	2B Cell 2	2B Cell 1	All Area A	1.15E+05
2013	2B Cell 3	2B Cell 2	2A and 2B Cell 1	1.15E+05
2014	2B Cell 4	2B Cell 3	2A and 2B Cell 2	1.15E+05
2015	2B Cell 5	2B Cell 4	2A and 2B Cell 3	1.15E+05
2016	2B Cell 6	2B Cell 5	2A and 2B Cell 4	1.15E+05
2017	2B Cell 7	2B Cell 6	2A and 2B Cell 5	1.15E+05
2018	2C Cell 1	2B Cell 7	2A and 2B Cell 6	1.15E+05
2019	2C Cell 2	2C Cell 1	All Areas A and B	1.15E+05
2020	2C Cell 3	2C Cell 2	2A, 2B and 2C Cell 1	1.15E+05
2021	2C Cell 4	2C Cell 3	2A, 2B and 2C Cell 2	1.15E+05
2022	2C Cell 5	2C Cell 4	2A, 2B and 2C Cell 3	1.15E+05
2023	2C Cell 6	2C Cell 5	2A, 2B and 2C Cell 4	1.15E+05
2024	2C Cell 7	2C Cell 6	2A, 2B and 2C Cell 5	1.15E+05
2025	2C Cell 8	2C Cell 7	2A, 2B and 2C Cell 6	1.15E+05
2026	2D Cell 1	2C Cell 8	2A, 2B and 2C Cell 7	1.15E+05
2027	2D Cell 2	2D Cell 1	All Areas A, B and C	1.15E+05
2028	2D Cell 3	2D Cell 2	2A, 2B, 2C and 2D Cell 1	1.15E+05
2029	2D Cell 4	2D Cell 3	2A, 2B, 2C and 2D Cell 2	1.15E+05
2030	2D Cell 5	2D Cell 4	2A, 2B, 2C and 2D Cell 3	1.15E+05
2031	2D Cell 6	2D Cell 5	2A, 2B, 2C and 2D Cell 4	1.15E+05
2032	2E Cell 1	2D Cell 6	2A, 2B, 2C and 2D Cell 5	1.15E+05
2033	2E Cell 2	2E Cell 1	All Areas A, B, C and D	1.15E+05
2034	2E Cell 3	2E Cell 2	2A, 2B, 2C, 2D and 2E Cell 1	1.15E+05
2035	2E Cell 4	2E Cell 3	2A, 2B, 2C, 2D and 2E Cell 2	1.15E+05
2036	2E Cell 5	2E Cell 4	2A, 2B, 2C, 2D and 2E Cell 3	1.15E+05
2037	2E Cell 6	2E Cell 5	2A, 2B, 2C, 2D and 2E Cell 4	1.15E+05
2038		2E Cell 6	2A, 2B, 2C, 2D and 2E Cell 5	
2039			All Areas	

Assumed Cell areas

Area	Basal Area (m ²)	Top Area (m ²)
2A Cell 1+2(N)	19500	21450
2A Cell 1+2(S)	16500	18150
2A Cell 3 (N)	15000	16500
2A Cell 3 (S)	13100	14410
2B Cell 1	7900	8700
2B Cell 2	7900	8700
2B Cell 3	7900	8700
2B Cell 4	7900	8700
2B Cell 5	7900	8700
2B Cell 6	7900	8700
2B Cell 7	7900	8700
2C Cell 1	10700	11800
2C Cell 2	10700	11800
2C Cell 3	10700	11800
2C Cell 4	10700	11800
2C Cell 5	10700	11800
2C Cell 6	10700	11800
2C Cell 7	10700	11800
2C Cell 8	10700	11800
2D Cell 1	5900	6500
2D Cell 2	5900	6500
2D Cell 3	5900	6500
2D Cell 4	5900	6500
2D Cell 5	5900	6500
2D Cell 6	5900	6500
2E Cell 1	11600	12700
2E Cell 2	11600	12700
2E Cell 3	11600	12700
2E Cell 4	11600	12700
2E Cell 5	11600	12700
2E Cell 6	11600	12700

Phase 2A Cell 1+2 North

Code

Effective Rainfall- Operational (mm/yr) 338 mm/yr

Effective Rainfall- Temporary Cap (mm/yr) 150 mm/yr

Effective Rainfall- Permanent Cap (mm/yr) 30 mm/yr

Drainable Porosity (fraction) 0.065 fraction by volume

Trigger Level for leachate head (m) 1 m above base

Waste absorptive capacity 0.0200 m³/t

Calculation																		
Year			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		TLV from previous year - EL from previous year																
Leachate Volume at Start of year (m ³)	LVto		0	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5
INPUTS																		
Waste Input rate (t/annum)	WIR		115000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Areas																		
Top Area of Operational Cells (m ²)	AToc		21450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Area of Temporary Capped Cells(m ²)	ATtc		0	21450	0			0										
Top Area of Permanently Capped Cells(m ²)	ATpc				21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450
Basal Areas																		
Basal Area (m ²)	AB		19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500
Rainfall Volumes																		
Rainfall Volume entering Operational Cells (m ³ /yr)	RVoc	ER/1000*AToc	7250.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall Volume entering Temporary Capped Cells (m ³ /yr)	RVtc	Err/1000*ATtc		3217.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall Volume entering Permanently Capped Cells (m ³ /yr)	RVpc	Erp/1000*ATpc	0	0	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Total Volume of water entering landfill (m ³ /yr)	INVol	RVoc+RVtc+RVpc	7250.1	3217.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
ABSORPTIVE CAPACITY																		
Absorptive Capacity at start of year (m ³)	ACto	RAC from previous year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional absorptive capacity from waste input (m ³)	ACt	WIR*AC	2300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total absorptive capacity of landfill (m ³)	TAC	ACto + ACt	2300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Absorptive Capacity at end of year (m ³)	RAC	If (TAC-INVol)>0, TAC-INVol, if not true no RAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEACHATE VOLUMES																		
Volume of Leachate Generated in year (m ³)	LG	If (TAC-INVol)>0, no leachate generated, if not true INVol-TAC	4950.1	3217.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Total Volume of Leachate present at end of year (m ³)	TLV	LVto+ LG	4950.1	4485	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911
Permitted Leachate Volume (m ³)	PLV	Lh*AB*P	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5
Depth of leachate without abstraction (m)	Ld	TLV/(AB*P)	3.91	3.54	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE																		
Excess Leachate Volume for removal (m ³ /year)	EL	If TLV>PLV, (TLV-PLV), otherwise 0	3682.6	3217.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Excess Leachate Volume for removal (m ³ /week)	EL/52		70.82	61.88	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38

Phase 2A Cell 1+2 North

Effective Rainfall- Operational (mm/yr)
Effective Rainfall- Temporary Cap (mm/yr)
Effective Rainfall- Permanent Cap (mm/yr)
Drainable Porosity (fraction)
Trigger Level for leachate head (m)
Waste absorptive capacity

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Leachate Volume at Start of year (m ³)	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5
INPUTS																				
Waste Input rate (t/annum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Areas																				
Top Area of Operational Cells (m ²)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Area of Temporary Capped Cells(m ²)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Area of Permanently Capped Cells(m ²)	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450	21450
Basal Areas																				
Basal Area (m ²)	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500	19500
Rainfall Volumes																				
Rainfall Volume entering Operational Cells (m ³ /yr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall Volume entering Temporary Capped Cells (m ³ /yr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall Volume entering Permanently Capped Cells (m ³ /yr)	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Total Volume of water entering landfill (m ³ /yr)	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
ABSORPTIVE CAPACITY																				
Absorptive Capacity at start of year (m ³)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional absorptive capacity from waste input (m ³)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total absorptive capacity of landfill (m ³)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Absorptive Capacity at end of year (m ³)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEACHATE VOLUMES																				
Volume of Leachate Generated in year (m ³)	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Total Volume of Leachate present at end of year (m ³)	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911	1911
Permitted Leachate Volume (m ³)	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5	1267.5
Depth of leachate without abstraction (m)	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
LEACHATE FOR REMOVAL TO ENSURE COMPLIANCE																				
Excess Leachate Volume for removal (m ³ /year)	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5	643.5
Excess Leachate Volume for removal (m ³ /week)	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38

APPENDIX LMP2

LANDSIM OUTPUT

Calculation Settings

Number of iterations: 1001

Results calculated using sampled PDFs

Maximum Head Calculation

Clay Liner:

Unretarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Unretarded values used for simulation

No Biodegradation

Saturated Vertical Pathway:

Unretarded values used for simulation

No Biodegradation

Aquifer Pathway:

Unretarded values used for simulation

No Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Ammoniacal_N	Non-Volatile
c (kg/l): 0.59	m (kg/l): 0
Chloride	Non-Volatile
c (kg/l): 0.2919	m (kg/l): 0.0298
Mercury	Non-Volatile
c (kg/l): 0.1643	m (kg/l): 0.0767

Background Concentrations of Contaminants

Justification for Contaminant Properties

Unjustified value

All units in milligrams per litre

Phase: Phase 1

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268,26.8)
End of filling (years from start of waste deposit):	4
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration
Unjustified value

Duration of management control (years from the start of waste disposal): 60

Cell dimensions

Cell width (m):	185
Cell length (m):	56.67
Cell top area (ha):	1.1334
Cell base area (ha):	1.0484
Number of cells:	6
Total base area (ha):	6.29037
Total top area (ha):	6.8004
Head of Leachate when surface water breakout occurs (m)	SINGLE(4)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(6,24)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste dry density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry
Unjustified value

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Ammoniacal_N	LOGTRIANGULAR(4.37,723,3640) <i>Data are spot measurements of Leachate Quality</i>
Chloride	LOGTRIANGULAR(36.6,2270,7760) <i>Data are spot measurements of Leachate Quality</i>
Mercury	LOGTRIANGULAR(3.94e-005,8.91e-005,0.00195) <i>Substance to be treated as List 1</i>

Justification for Species Concentration in Leachate
Unjustified value

Drainage Information

Type of drainage:	Blanket
Calculate flow from given parameters:-	
Slope to sump:	1 on 50 (1.1°)
Edge	
Sump radius (m):	0.45
Blanket thickness(m):	0.5
Blanket drain conductivity (m/s):	LOGUNIFORM(0.0001,0.001)

Justification for Drainage Blanket
Unjustified value

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
Unjustified value

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNDEFINED
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)

Justification for Clay: Liner Thickness
Unjustified value

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(3e-010,4.35e-010,1e-009)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
Unjustified value

Retardation parameters for clay liner
No retardation values used in this simulation.
Check 'Unretarded Contaminant Transport' setting under simulation preferences.

pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNDEFINED
Flow Model:	porous medium
Pathway moisture content (fraction):	UNDEFINED
Pathway Density (kg/l):	UNDEFINED

Justification for Unsat Zone Geometry
Unjustified value

Pathway hydraulic conductivity values (m/s):	UNDEFINED
--	-----------

Justification for Unsat Zone Hydraulics Properties
Unjustified value

Pathway longitudinal dispersivity (m):	UNDEFINED
--	-----------

Justification for Unsat Zone Dispersion Properties
Unjustified value

Retardation parameters for pathway

Modelled as unsaturated pathway

No retardation values used in this simulation.

Check 'Unretarded Contaminant Transport' setting under simulation preferences.

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(120,1020)
Pathway width (m):	UNDEFINED

pathway parameters

Modelled as vertical pathway.

Pathway length (m):	UNDEFINED
Pathway porosity (fraction):	UNDEFINED

Justification for Vertical Path Geometry

Unjustified value

Pathway dispersivity (m):	UNDEFINED
---------------------------	-----------

Justification for Vertical Path Dispersion Details

Unjustified value

Retardation parameters for pathway

Modelled as vertical pathway.

No retardation values used in this simulation.

Check 'Unretarded Contaminant Transport' setting under simulation preferences.

pathway parameters

Modelled as aquifer pathway.

Mixing zone (m):

UNDEFINED

Justification for Aquifer Geometry
Unjustified value

Pathway regional gradient (-):

UNDEFINED

Pathway hydraulic conductivity values (m/s):

UNDEFINED

Pathway porosity (fraction):

UNDEFINED

Justification for Aquifer Hydraulics Properties
Unjustified value

Pathway longitudinal dispersivity (m):

UNDEFINED

Pathway transverse dispersivity (m):

UNDEFINED

Justification for Aquifer Dispersion Details
Unjustified value

Retardation parameters for pathway
Modelled as aquifer pathway.
No retardation values used in this simulation.
Check 'Unretarded Contaminant Transport' setting under simulation preferences.



September 2011

WITHYHEDGE LANDFILL

Leachate Management System Review

Submitted to:

SITA UK Ltd
301-304 Parkway
Worle
Weston-Super-Mare
Somerset
BS22 6WA

REPORT



Report Number. 11514290005.501/A.0

Distribution:

SITA UK Ltd - 1 copy (pdf)
Golder Associates (UK) Ltd - 1 copy





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1.0 INTRODUCTION

1.1 Terms of Reference

SITA UK Ltd ('SITA') has requested that Golder Associates (UK) Ltd ('Golder') produces a Leachate Management System Review for Withyhedge Landfill Site (the Site).

The assistance of SITA in the provision of data for this work is gratefully acknowledged. Golder has not independently verified any of the information supplied.

1.2 Background

We understand that SITA is looking to review its leachate management system at the Site and to implement upgrades to the existing system where appropriate, in response to Improvement Conditions 2a and 2b of the Environmental Permit (EPR/BP3131SG/V004) which state:

2a: *'The Operator shall submit to the Agency, for approval, a report assessing the effectiveness of current leachate abstraction versus the risk of retro drilling new leachate monitoring wells for cells 1 - 10 and 12 to allow a compliance limit to be set for inclusion in Table s4.1. The report should seek to establish basal lining contours, review existing infrastructure including the need for extension of abstraction and monitoring network in terms of number of points and depths in order to achieve leachate monitoring levels and/or abstraction rates on site that can be demonstrated to minimise leachate heads and encourage hydraulic containment in accordance with the Agency Guidance document 'Guidance on monitoring of landfill leachate, groundwater and surface water (LFTGN02)'. Submission of this improvement condition to the Agency is required by 16 September 2011.*

2b: *'On written approval from the Agency any new monitoring points required by 2a above shall be installed, in accordance with conditions 2.6.4 and 2.6.6, and the relevant leachate management and monitoring plans updated.'* Completion of this improvement condition is required within 6 months of receipt of written approval from the Agency.

1.3 Objectives

This report addresses Improvement Condition 2a. The objectives of the report are to:

- Prepare a water balance including estimates of leachate generation from rainfall, contribution from groundwater flow, changes in leachate storage and rates of leachate abstraction;
- Establish basal lining contours for Phase 1 Cell 1 to 10 and 12, and review existing infrastructure; and
- Provide recommendation for infrastructure improvements where appropriate based on the effectiveness of the current leachate abstraction system in accordance with the requirements of the Improvement Condition.

1.4 Report Structure

The structure of the report is as follows:

- Section 2.0 describes the existing site situation;
- Section 3.0 describes a Site water balance;
- Section 4.0 presents a review of the leachate management infrastructure based upon results of the water balance;
- Section 5.0 presents the proposed leachate management strategy for Phase 1 Cells 1 to 10 and 12 to address Improvement Condition 2a;
- Section 6.0 presents the recommendations for retro-drilling and for establishing compliance limits.



2.0 EXISTING SITE SITUATION

2.1 Site Location and Setting

The Site is located approximately 5.5 km north of Haverfordwest in Pembrokeshire at National Grid Reference SM 970 217. It is bounded to the north by Rudbaxton Water, and to the east, south and west by agricultural land.

Access to the Site is from a turning off the A40 close to Haverfordwest Airport, along Fletcher Hill, which leads to a 1.5 km long access road of tarmac construction. At the top of the access road is a weighbridge.

The catchment of Rudbaxton Water comprises a shallow valley, of which the Site is located on the southern flank. The valley slopes gently towards the west. Rudbaxton Water is at an elevation of approximately 30 to 40 m AOD.

2.2 Site Phasing, Construction and Operation

Before development of the landfill, the Site had been in use for agricultural purposes. The Site was run by Pembrokeshire County Council under a Resolution and accepted waste from 1985. Planning consent and a Waste Management Licence was awarded to Resource Management Ltd ('RML') in January 1996 (WML SWW/163/L) under the Waste Management Licensing Regulations (1994). The Site operates as a non-hazardous waste landfill, and has not accepted hazardous waste since 16 July 2004. Phase 1 accepted its final waste in December 2006. A PPC Permit was granted for landfilling in the area to the west of the existing Site (Phase 2) on 8 September 2006. The Site is currently operated under Environmental Permit EPR/GP3630HT-V002 that covers both Phase 1 and Phase 2.

The layout of the Site and the phasing of the waste deposition are presented in Drawing 501/1.

Phase 1 covers an area of 17.8 ha and has a total of fifteen cells. Much of this area operated on a dilute and disperse basis (Cells 1 to 10 and 12), however, four of the landfilled phases (Cells 11, 13, 14 and 15) have been engineered with artificially established mineral barriers. The exact layout of Cells 1 to 10 and 12 is unknown.

Phase 2 covers a total area of 34.1 ha and to date has a total of six engineered cells (Cells 1 and 2 North, Cells 1 and 2 South, Cell 3 South and Cell 3 North), which cover an area of approximately 7.05 ha. Cell 3 north is currently operational.

A description of the construction of each cell in Phases 1 and 2 are presented in the following sections.

2.2.1 Phase 1 Cells 1 to 10 and 12

Waste within Phase 1 Cells 1 to 10 and 12 was deposited by Preseli Pembrokeshire District Council (PPDC). AIG Consultants (2003) report:

"It is believed that PPDC commenced landfilling in the south eastern part of the "existing site" on a dilute and disperse basis, with infilling being undertaken beneath a Somerset Litter Net to form a series of east-west orientated unconfined "cells" approximately 30 m in width. Within the "existing site" it is believed that the base of the waste mass placed by PDCC to be at elevations of between 47 and 48 m OD, although no accurate records of landfill engineering by PPDC during the early phases of installation development are available."

RML, the previous operator of the Site, has reported that where further material was required for road building, more material was removed and therefore it is likely that parts of the Site have been excavated to greater depth. Historical photographs of the Site viewed by Golder in the past indicate that the area in which this occurred was a strip approximately parallel with Cell 11 towards the centre of the Site.

It is understood that the excavated material comprised topsoil and natural clays. The base of the cells are therefore likely to lie on the Mydrim Shale. It is reported by RML that the southern area of Cells 1 to 10 and 12 was clay lined. However, the clay was not engineered to a permeability specification and no Construction Quality Assurance (CQA) was undertaken prior to waste deposition. The permeability of the clay base is



therefore unknown. The northern area is believed to also be lined with clay, however to a much smaller thickness (maximum of 300 mm) and this was also not engineered to a permeability specification or subject to CQA.

It is unknown whether additional material was removed after clay placement and therefore whether in some parts of Phase 1 clay is not present in the cell base, and waste may therefore have been directly deposited onto the Mydrim Shale beneath.

Work undertaken by Golder to develop the basal levels of gas wells in Phase 1 (Golder, 2007) estimated the basal levels of Cells 1 to 10 and 12 based upon original ground contours across the area prior to waste deposition. Basal elevations are shown to vary between 45.5 m AOD in the north of the area and 54.4 m AOD in the south. This is reasonably consistent with estimates given in the AIG Consultants report (2003).

2.2.2 Phase 1 Cell 11

Cell 11 is a rectangular shape located along the northern boundary of Phase 1. The basal liner comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s. A 5 m high clay bund was constructed along the northern edge (CL Associates, 1995).

2.2.3 Phase 1 Cell 13

Cell 13 is a crescent shape located in the southwestern corner of Phase 1. It has a basal area of approximately 11,500 m². The basal lining system comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s (AIG Consultants Ltd., 2001). The base of Cell 13 is 46.5 m AOD, increasing to 50 m AOD at the outer edges.

2.2.4 Phase 1 Cell 14

Cell 14 is a broad rectangular shape located in the northwestern area of Phase 1. It has a basal area of approximately 6000 m². The basal liner comprises 1 m thick engineered clay with a permeability of not more than 1×10^{-9} m/s (AIG Consultants Ltd., 2002). Cell 14 basal elevations range from 48.7 m AOD to 45 m AOD at the collection sump.

2.2.5 Phase 1 Cell 15

Cell 15 is approximately rectangular and has an area of approximately 20,000 m². It is located in the northwestern corner of Phase 1. The basal liner comprises 1 m thick engineered clay with a maximum permeability of 1×10^{-9} m/s. The engineered clay is overlain by a 2 mm thick smooth HDPE geomembrane, which is overlain by a protective geotextile (AIG Consultants Ltd., 2004). Based on the as built drawings for Cell 15, basal elevations range from 45.45 to 48.3 m AOD.

2.2.6 Phase 2 Cells 1 and 2 North

Cells 1 and 2 North are rectangular shaped and have a basal area of approximately 17,030 m². The basal lining system comprises a 1 m thick layer of engineered clay with a maximum permeability of 1×10^{-9} m/s, overlain by a 2 mm thick textured high density polyethylene (HDPE) geomembrane and protective geotextile. All clay liner construction comprises clay excavated from the site (Golder, 2006). Cells 1 and 2 North basal elevations range from approximately 46.8 to 44.7 m AOD at the collection sump.

2.2.7 Phase 2 Cells 1 and 2 South

Cells 1 and 2 South are rectangular shaped and located to the south of Cells 1 and 2 North. They have a basal area of approximately 14,590 m². The basal lining system comprises a 0.5 m thick layer of engineered clay with a maximum permeability of 1.0×10^{-8} m/s overlain by a Geosynthetic Clay Liner (GCL) with a maximum permeability of 1.0×10^{-11} m/s and a 2 mm thick textured high density polyethylene (HDPE) geomembrane. This geomembrane is overlain by a protective geotextile and a gravel drainage blanket and filter geotextile. The clay liner comprises clay excavated from the site (Golder, 2008a). Cells 1 and 2 south basal elevations range from approximately 48 to 46.6 m AOD.



2.2.8 Phase 2 Cell 3 South

Cell 3 South is rectangular shaped and is located adjacent to the west of Cells 1 and 2 South. It has a basal area of approximately 11,860 m². The basal lining system comprises a 0.5 m thick layer of engineered clay with a maximum permeability of 1.0×10^{-8} m/s overlain by a Geosynthetic Clay Liner (GCL) with a maximum permeability of 1.0×10^{-11} m/s and a 2 mm thick textured high density polyethylene (HDPE) geomembrane. This geomembrane is overlain by protective geotextile, gravel drainage blanket and filter geotextile. The clay liner construction comprises clay excavated from the site (Golder, 2008b). Cell 3 south basal elevations range from approximately 46 to 43 m AOD.

2.2.9 Phase 3 Cell 3 North

Cell 3 North is rectangular shaped and is located to the north of Cell 3 South. It has a basal area of approximately 13,350 m². The basal lining system comprises a 0.5 m thick layer of engineered clay with a maximum permeability of 1.0×10^{-8} m/s overlain by a Geosynthetic Clay Liner (GCL) with a maximum permeability of 1.0×10^{-11} m/s and a 2 mm thick textured high density polyethylene (HDPE) geomembrane. This geomembrane is overlain by a protective geotextile, gravel drainage blanket and filter geotextile. The clay liner construction comprises clay excavated from the site (Golder, 2009). Cell 3 South basal elevations range from 44.5 to 42 m AOD.

2.3 Leachate Management Infrastructure

2.3.1 Leachate Extraction

A pneumatic pump system was installed in August/September 2009. 3" or 4" pumps were introduced into Phase 1 Cells 1 to 10 and 12 (LD3), Cell 11 (11W and 11E), Cell 14 (Cell 14 sump) and Cell 15 (Cell 15 sump) and Phase 2 Cell 1 (L1), Cell 2 (L2) and Cell 3 (L3). These form the northern main. In addition pumps are installed in Phase 1 Cells 1 to 10 and 12 (SW sump) and Cell 13 (Cell 13 sump) and form the southern main. Both mains comprise a 90 mm HDPE pipe and feed the leachate storage tanks located in the south eastern corner of the Site. Air is provided by a 100 cfm compressor. All three tanks have automated float switches which switch off the pump system once the tanks are full. The pumps within the wells are installed 100 mm from the base of the wells. A minimum water level of 780 mm above the base of the well is required for the pumps to operate. Pumping occurs to maintain the water level below a control level of 900 mm above the base of the wells.

The pneumatic system currently pumps approximately 100 m³ per 24 hours. The system has been fully operational for approximately one year and the flow volume recorded at the entry to the leachate storage tanks is currently 28,909 m³. SITA reports that this is therefore considered representative of approximately one year of pumping.

Pumps in Phase 1 Cells 1 to 10 and 12 (SW Sump and LD3) have been operational since October 2009. SITA reports that on 6 July 2011 total pumping volumes of 390,122 litres and 24,063 litres had been pumped from SW Sump and LD3, respectively. This corresponds to approximately 232 m³/yr and 14 m³/yr, respectively.

At present, particularly in winter months, the pump system is supplemented by use of a vacuum tanker which extracts additional leachate from Cells 13 and 15 in Phase 1, and Cells 1 and 2 North and Cell 3 North in Phase 2. Leachate extracted by this method is also stored within the leachate storage tanks. Volumes extracted by this method for the period January 2010 to April 2010 and October 2010 to December 2010 are presented in Table 501/1. It is noted that the tractor was deployed during May 2010 to September 2010 on an infrequent basis however records were not kept. The volumes presented are therefore likely to represent an underestimate of the total leachate abstracted.

Table 501/1: Volumes of Leachate Extracted using Vacuum Tanker, January 2010 to December 2010

Phase	Cell (Well)	Volume of Leachate Extracted (m ³)
Phase 1	Cell 13 (Cell 13 Sump)	2,918.6
	Cell 15 (Cell 15 Sump)	5,702.6
Phase 2	Cell 1 North (L1)	4,548.8



Phase	Cell (Well)	Volume of Leachate Extracted (m ³)
	Cell 2 North (L2)	3,802.3
	Cell 3 North (L3)	407.3
	TOTAL	17,379.7

The leachate extraction system constructed within each cell is described in the following sections.

2.3.1.1 Phase 1 Cells 1 and 10 and 12

Leachate is managed within Cells 1 to 10 and 12 by a 300 mm diameter perforated perimeter collection pipe which extends around the southern and eastern perimeter of the Site as shown on Drawing 501/1. The pipework is set within a 20 mm gravel filled trench. The pipe falls from the southeast corner of Phase 1 from an invert elevation of 54.96 m AOD westwards to an invert elevation of 51.87 m AOD at its closest point to Cell 13 (SW Sump). The pipe also falls northwards to the northeastern corner (LD3). The collection sumps comprise 1200 mm diameter concrete rings set on to a concrete base and tanked using bitumen and bentonite slurry. The main objective of this pipe is to prevent leachate breakout along these boundaries of the Site.

2.3.1.2 Phase 1 Cells 11, 13, 14 and 15

Formal leachate drainage systems have been installed at the point of construction within Cell 11, Cell 13, Cell 14 and Cell 15. These leachate drainage systems are as follows;

Cell 11: Spinal leachate collection system falling from the mid point of the cell towards two leachate collection chambers, 11W to the west and 11E to the east, at a gradient of 1 in 50. The collection pipes comprise perforated 150 mm diameter HDPE pipe set within 40 mm gravel. The leachate collection chambers comprise perforated 900 mm diameter HDPE towers and concrete bases.

Cell 13: The leachate collection chamber comprises perforated 900 mm diameter HDPE tower and concrete base at an elevation of 46.5 m AOD. This is connected to two 150 mm diameter spine drains falling from the cell perimeter towards the sump at a gradient of 1:50. The spine drains are set within 40 mm gravel.

Cell 14: The leachate collection chamber comprises perforated 900 mm diameter HDPE tower and concrete base at an elevation of 45 m AOD. This is connected to 150 mm diameter drains in a herringbone pattern falling towards the sump at a gradient of 1:100. The drains are set within 40 mm gravel.

Cell 15: The leachate collection chamber comprises perforated 900 mm diameter HDPE tower and concrete base at an elevation of 44 m AOD. This is connected to a herringbone pattern of leachate pipework set within a 500 mm thick basal stone drainage blanket.

2.3.1.3 Phase 2 Cells 1 and 2 North, Cells 1 and 2 South, Cell 3 South and Cell 3 North

Formal leachate drainage systems have been installed at the point of construction within Cells 1 and 2 North, Cells 1 and 2 South, Cell 3 South and Cell 3 North. The specification of these leachate drainage systems are:

Cells 1 and 2 North: The leachate drainage blanket has a total thickness of 500 mm on the base of the cells and comprises natural alluvial gravels with a particle size between 2 and 125 mm. The blanket comprises a lower 150 mm thick layer of 5 to 20 mm gravel overlain by an upper 350 mm thick layer of 2 to 125 mm gravel. The leachate collection and removal system also comprises a network of perforated HDPE pipes placed on a layer of gravel and covered by 20 mm single sized bedding surround. Leachate collection chambers are located in the north of each cell (L1 and L2).

Cells 1 and 2 South: The leachate drainage blanket has a total thickness of 300 mm on the base of the cells and comprises natural crushed rock gravel with a nominal particle size range of between 10 and 20 mm. The leachate collection and removal system also comprises a 150 mm diameter HDPE main spine drain with 100 mm diameter HDPE feeder pipes at a maximum of 50 m centres. In addition, the main spine



drain has been connected to the existing pipework of Cells 1 and 2 (North), which are extended through the northern intercell bund of Cells 1 and 2 (South). Leachate collection chambers are located in the north of each cell (L4 and L5).

Cell 3 South: The leachate drainage blanket has a total thickness of 300 mm on the base of the cells and comprises natural crushed rock gravel with a nominal particle size range of between 10 and 20 mm. The leachate collection and removal system also comprises a 160 mm diameter HDPE main spine drain with 120 mm diameter HDPE feeder pipes at a maximum of 30 m centres.

Cell 3 North: The leachate drainage blanket has a total thickness of 300 mm on the base of the cells and comprises natural crushed rock gravel with a nominal particle size range of between 10 and 20 mm. The leachate collection and removal system also comprises a 160 mm diameter HDPE main spine drain with 120 mm diameter HDPE feeder pipes at a maximum of 30 m centres. The main spine drain has been connected to the existing pipework of Cell 3 South. A leachate collection chamber is located in the north of the cell (L3).

2.3.2 Leachate Storage

Leachate is stored prior to disposal in three leachate storage tanks located to the east of Phase 1. Leachate from both Phases 1 and 2 are stored within these tanks. The storage tanks each have a capacity of 54 m³ (a total of 162 m³ for the three tanks) and are integrally bunded in line with accepted industry standards.

2.3.3 Leachate Disposal

Leachate pumped from the cells by the pneumatic pump system, and by vacuum tanker, is stored in the leachate storage tanks prior to tankering for off-site treatment and disposal at an appropriate facility. Tankering typically occurs 5 ½ days a week, but can be, and is on occasion increased to 7 days a week.

Volumes of leachate tankered from the Site during 2008 to 2010 are presented in Appendix 501/1 and values for 2010 presented in Table 501/2.

Table 501/2: Volumes of Leachate Tankered from the Site in 2010

	Volume Tankered (m ³)
January	8,828
February	7,965
March	4,055
April	3,227
May	1,637
June	1,922
July	3,228
August	2,254
September	2,165
October	3,592
November	6,329
December	6,081
TOTAL	51,283

2.4 Leachate Monitoring

2.4.1 Leachate Monitoring Infrastructure

The permit requires that in Phase 1 leachate quality and levels are monitored from the leachate extraction sumps in Cells 1 to 10 and 12 (SW Sump and LD3), 11 (Cell 11W and 11E Sumps, also known as Sump B



and Sump C), 13 (Cell 13 Sump), 14 (Cell 14 Sump) and 15 (Cell 15 Sump) and three monitoring wells in Cells 1 to 10 and 12 (LW1, LW2 and LW4). Leachate levels are to be monitored on a monthly basis.

In Phase 2 the permit requires that leachate quality and levels are monitored from the leachate extraction sumps in Cells 1 and 2 North, Cells 1 and 2 South, Cell 3 South and Cell 3 North (L1 to L5) and leachate levels in remote monitoring points (LM1, LM2, LM3N, LM3S, LM4 and LM5). Leachate levels are to be monitored on a weekly basis

The locations of leachate monitoring wells are shown on Drawing 501/1.

2.4.2 Leachate Levels

Leachate levels are currently monitored in Phase 1 in LW1, LW2, LW4, SW Sump, LD3, Cell 11W Sump, Cell 11E Sump, Cell 13 Sump, Cell 14 Sump and Cell 15 Sump. In Phase 2 leachate levels are monitored in L1 to L5, LMP1, LMP2, LMP3N, LMP3S, LMP4 and LMP5.

Table S4.1 of the Permit states that the leachate head should not exceed 1 m above the cell basal liner in all cells in Phases 1 and 2.

Leachate level hydrographs for the period January 2010 to January 2011 (with the exception of in Phase 1 Cells 1 to 10 and 12 where data is infrequent during 2010 so data from January 2009 onwards has also been included) are presented in Appendix 501/2. It is noted that a number of data points are shown to be negative and that there is a step change in the data for LM3N. Golder has not independently verified any of the data.

Hydrographs show that in Phase 1 Cell 1 to 10 and 12 which are unengineered, leachate levels show a gradual increase during 2009 and 2010 of approximately 1 m. Levels are very variable between monitoring wells but do not show short term fluctuations. Levels have been consistently above the compliance level of 1 m above the cell basal liner in wells LW1 and LW2 but consistently below the compliance level in LW4.

Eighty one gas wells were installed across Phase 1 during 2009. Leachate levels have also been recorded in some of these wells, each on one occasion, during the period September 2010 to May 2011. The leachate levels taken from within Cells 1 to 10 and 12 have been contoured and are shown on Drawing 501/2. These show higher levels in the centre of the Site with an indication of radial flow towards the periphery.

Leachate levels in Phase 1 engineered Cells 11, 13, 14 and 15 show a reduction since the beginning of 2010. Up until summer 2010 leachate levels in Cells 11, 13, 14 and 15 were typically above the compliance level of 1 m above the base of the cells. However, since summer 2010 leachate levels in all cells have reduced to below the compliance level of 1 m above the base of the cell. Rapid fluctuations of up to 1 m are commonly observed, likely a result of pumping.

Leachate levels in Phase 2 engineered cells, Cells 1 and 2 North, Cells 1 and 2 South, Cell 3 South and Cell 3 North show reasonably steady leachate levels during 2010 with only short term periods above the compliance level of 1 m above the base of the cells.

2.5 Groundwater Management System

A groundwater cut off wall was constructed in 1995 with the intention of diverting the north westerly flow of groundwater around the periphery of Phase 1. A trench was constructed 500 mm into the shale below and sealed using bentonite cement slurry. Bentonite matting was used to form a low permeability barrier within the trench prior to backfilling with compacted clay. The trench extends along the southern, eastern and southern most part of the western boundaries (to the west of Cell 13). At its western end the trench is over 4.5 m deep and therefore extends to approximately 44.5 m AOD (CL Associates, 1996).

Groundwater level hydrographs for the period January 2009 to January 2011 are presented in Appendix 501/3. Groundwater contours for August 2010 and December 2010, the approximate seasonal low and high respectively, are presented on Drawing 501/1. These show that in the south eastern corner of the Site where the groundwater cut off wall is located groundwater levels range from 50 to 52 m AOD. At the western end where the base of the trench is expected to lie at approximately 44.5 m AOD, groundwater



levels range from 45 to 47 m AOD. Whilst it is therefore expected that groundwater will be intercepted by the cut off wall, groundwater contours indicate that there is no significant effect on groundwater levels down gradient of the trench, only a slightly less steep groundwater gradient, suggesting that the trench is not fully diverting groundwater around the site and could therefore enter the waste in Cells 1 to 10 and 12, the base of which lies at approximately 47 to 48 m AOD.

2.6 Surface Water Management System

The surface water management system for Phase 1 comprises two surface water lagoons and a series of collection ditches located around the perimeter of Phase 1. The scheme is designed to attenuate the large volumes of surface water run-off generated during rainfall and to remove the suspended sediment from the run off prior to discharge across the northern boundary into Rudbaxton Water. The lagoons are designed to manage the peak flow of a 1 in 10 year storm event.

Surface water management for Phase 2 comprises surface water collection ditches around the perimeter and two surface water collection lagoons located on the western site boundary. These lagoons discharge via points known as D2 and D3 into Rudbaxton Water, although D3 has not yet been constructed.

The spring to the south of the Site that currently flows through the Phase 2 area will be diverted along the southern boundary of the Site to the lagoon to the west of the installation boundary once construction progresses into that area.

2.7 Status of Capping and Restoration

The majority of Phase 1 is permanently capped with overlapped geomembrane and clay composite onto which subsoil and topsoil restoration materials have been placed. An area of Cells 1 to 10 and 12 (13,500 m²), where a skip park is currently located, Cell 13 and the western part of Cell 15 are temporary capped. Permanent capping will take place during 2012.

In Phase 2, a temporary cap was installed in March 2010 on Cells 1 and 2 North. The remaining cells remain open waste.

3.0 SITE WATER BALANCE

3.1 Introduction

A water balance calculation has been undertaken to consider the potential for generation of excess leachate at the Site (the volume requiring removal) and therefore whether the capacity of the leachate storage and disposal system is sufficient.

This water balance aims to compare the quantities of water entering and leaving the waste during specified time periods. Any imbalance between water input and water output will lead to a change in the quantity of liquid held in the waste as leachate.

Water is present in the landfill either as free leachate or absorbed onto or into solid waste materials. The amount held in each form depends on the storage characteristics of the waste. This varies depending on the type, source and age of the waste.

The water balance calculations are based on the standard water balance equation for any hydrologic system, where the rate of inflow minus the rate of outflow is equal to the rate of change of the quantity of water stored within the system. In its application to a landfill system, this equation is rearranged and combined with assumptions about the volume and storage characteristics of the waste. The volume of free leachate in a specified time period can be calculated using the following equation:



$$V_L = V_{(in)} - V_{(out)} - AW$$

Where

V_L Volume of free leachate in the landfill system (m^3)

$V_{(in)}$ Volume of water entering the landfill system (m^3)

$V_{(out)}$ Volume of water leaving the landfill system (m^3)

A Absorptive capacity of the waste ($m^3/tonne$)

W Waste input during the specified time period (tonne)

Water may enter the landfill as a result of effective rainfall, surface run-on, groundwater discharge, and leachate recirculation. Water can leave the landfill by evaporation, transpiration, surface run-off, surface seepage or springs, groundwater recharge, and leachate removal.

3.2 Components of the Water Balance

3.2.1 Effective Rainfall

Effective rainfall is commonly the major input to the water balance. It is defined as the amount of rainfall available for infiltration after run-off and evapotranspiration losses have been taken into account and any soil moisture deficit has been satisfied. A soil moisture deficit evolves as a result of an excess of evapotranspiration over rainfall.

At present in Phase 1 Cells 1 to 10 and 12 (with exception of a 13,500 m^2 area which is due to be permanently capped later in 2011), Cell 11, Cell 14 and approximately 6,092 m^2 along the eastern edge of Cell 15 are permanently capped. The remainder of Cell 15, and Cell 13, are temporary capped with fines material.

In Phase 2 Cells 1 and 2 North were temporary capped in March 2010. Cells 1 and 2 South and Cell 3 South are filled but uncapped. Cell 3 North is currently being filled, with an area approximately 6,890 m^2 at the northern end of the cell which has not had any waste deposited in it (Survey from December 2010).

Rainfall data for the Site indicates that for the period 2007 to 2011 annual rainfall has been recorded at between 937 and 1538 mm/yr (average of 1142 mm/yr). Evapotranspiration data obtained from MAFF (1976) indicates an annual value of 513 mm/yr. Based on this data, effective rainfall is estimated to be 660 mm/yr.

The effective rainfall through any temporarily capped areas of the Site is estimated to be 150 mm per year. Based on the permanent cap specification for the Site (LLDPE geomembrane), the effective rainfall infiltrating the waste is assumed to be 30 mm per year for permanently restored phases.

3.2.2 Surface Water Run-Off

The final restoration profile will be sufficiently steep so as to encourage run-off. Ground contours at the western edge of the permanent capping in Phase 1 are such that it is unlikely that rainfall falling on the capped areas will run-off and enter waste in the western temporary capped areas. Surface water run-on is therefore not included in the inputs and surface water run-off is not included in the outputs.

The area of Cell 3 North which has yet to be filled with waste, is lined with HDPE geomembrane. It is considered that rainfall could enter this area directly and runoff towards the collection sump. This will therefore contribute to the leachate generated within the cell, requiring removal. This has been included in the water balance.

3.2.3 Groundwater Inflow

Phase 2 is engineered to ensure that a 1 m unsaturated zone remains beneath the Site. Groundwater inflow to the waste is therefore assumed to be negligible and will not contribute to leachate production.



The engineered Cells 11, 13, 14 and 15 also have some unsaturated zone beneath them and it is therefore considered that groundwater inflow is negligible.

Cells 1 to 10 and 12 of Phase 1 have a groundwater cut-off drain around the southern and eastern boundaries of the Cells. At the western end the trench is over 4.5 m deep, extending to approximately 44.5 m AOD. Groundwater levels indicate that groundwater could cross the base of the waste and therefore groundwater inflow could occur. However, as shown in the cross sections presented in the HRA (Golder, 2008b), the groundwater is likely to flow beneath the leachate extraction drain, and therefore any inflow cannot be removed from the Site. Further, the quantities of groundwater flow are likely to be insignificant compared to recharge from rainfall and will therefore not be included in the water balance.

3.2.4 Storage Characteristics

As water percolates down through the Site, it may be absorbed by the porous components of the waste. Waste at field capacity is defined as the maximum amount of moisture that can be held by the waste against the pull of gravity. The absorptive capacity is defined as the maximum amount of water that can be taken up by the waste to take it from its initial moisture content to field capacity.

Estimates of absorptive capacity of refuse vary widely between authors, ranging from 0.02 m³/tonne (NWWDO, 1991) to 0.24 m³/tonne (Beaven and Powrie, 1995). Based on the findings of the literature review, a conservative value of 0.02 m³/tonne is considered appropriate. It should be noted, however, that this value might underestimate the absorptive capacity of the waste that is deposited at the Site.

Waste in Phase 1 was uncapped for over 15 years. It is therefore assumed that there is no remaining absorptive capacity in the waste.

In Phase 2 the majority of the waste mass is relatively shallow, approximately 10 m or less. Each cell in Phase 2 has to date taken approximately 1 year to fill. The calculated total absorptive capacity for each cell is calculated to be significantly less than the amount of water estimated to enter the cell during the year and therefore it is considered that absorptive capacity remaining in Cells 1 and 2 North, Cells 1 and 2 South and Cell 3 South is likely to be negligible and has therefore not been considered in the water balance.

Cell 3 North is being filled currently, however it is likely that the rate of waste input is such that absorptive capacity is used up relatively quickly. An average of 15,000 tonnes of waste is added in a 3 month period at present. This equates to an absorptive capacity of 300 m³. In a 3 month period in Cell 3 North an average infiltration to open waste is 1,779 m³ and therefore over this period the absorptive capacity will be used up and free leachate generated. Given the relatively small thickness of the waste mass it is considered that infiltration will likely penetrate the majority of the waste and the absorptive capacity utilised fully. For the purpose of the water balance absorptive capacity has not been included. This will provide a conservative estimate of leachate generation.

Where free leachate is present across the base of the Site, waste is saturated. The difference between the volume of water retained at field capacity, and that present at saturation is known as the drainable porosity. This has been used to estimate the available leachate storage resulting from saturation of the waste to the leachate compliance level (1 m above the base of the cell). A drainable porosity of 4.6% by volume has been assumed based upon work by Knox (2006) assuming up to 25 m thickness of waste. A leachate storage volume in each cell as a result of waste saturation has been estimated by applying this to a saturated volume equal to the basal cell area multiplied by the leachate head.

It is noted that at present leachate levels in all but Phase 1 Cells 1 to 10 and 12 remain steady and below compliance level of 1 m above the base of each cell. For the purposes of the water balance it is therefore assumed that there is no excess leachate above compliance level to be removed from the Site and that therefore the amount of leachate requiring abstraction is equal to the amount generated.

3.3 Water Balance Methodology

The water balance calculations have been undertaken using an excel spreadsheet. The calculations spreadsheets are presented in Appendix 501/4. For a 3 month period, the spreadsheet calculates the



volume of leachate produced within each cell (in the absence of any absorptive capacity, equal to the volume of water entering the cell).

Three scenarios have been calculated:

- Average Scenario- This has been based on the current status of filling capping and restoration. Infiltration to open waste values have been based upon average observed onsite rainfall values and average MAFF literature evapotranspiration values;
- Wet Period Scenario- This has also been based on the current status of filling capping and restoration. Infiltration to open waste has been based upon the maximum observed 3 month period of rainfall from 2007 to 2010 (525 mm from November 2009 to January 2010); and
- Capped Scenario- For this scenario it is assumed that permanent capping is undertaken on remaining filled cells, Phase 1 remaining area of Cells 1 to 10 and 12, Cells 13 and 15, Phase 2 Cells 1 and 2 North, Cells 1 and 2 South and Cell 3 South.

3.4 Summary of Results

The water balance has been used to predict the volume of leachate produced under the above scenarios. The estimated volumes are presented in Table 501/3.

Table 501/3: Predicted Volume of Leachate Produced during 3 Month Period (m³)

Phase	Cell	Average Scenario	Wet Scenario	Capped Scenario
Phase 1	Cells 1 to 10 and 12	3,085*	7,756*	959
	Cell 11	195	195	195
	Cell 13	325	325	65
	Cell 14	60	60	60
	Cell 15	465	465	130
Phase 2	Cells 1 and 2 North	981	981	196
	Cells 1 and 2 South	3,105	9,617	141
	Cell 3 South	2,584	8,002	117
	Cell 3 North	3,746	9,126	3,746
	TOTAL	14,547	36,528	5,609
Current total storage volume of leachate at compliance level		8,347		

Average scenario based upon average annual meteorological data.

Wet scenario based upon highest 3 month period of rainfall observed 2007 to 2011.

Capped scenario assumes permanent capping of all cells not including operational Cell 3 North.

** These values will be lower following permanent capping in 2012.*

4.0 REVIEW OF LEACHATE MANAGEMENT BASED ON WATER BALANCE

4.1.1 Effectiveness of Leachate Disposal Infrastructure

As shown in Table 501/1, the total volume tankered from Site during 2010 was 51,283 m³. This is reasonably consistent with the estimates provided by the pumping system (28,909 m³) and vacuum tanker (17,380 m³), given that this excludes a small amount of data during the summer months when no records were kept of the leachate extracted using the vacuum tanker.

The water balance predicts that under average conditions, a total of 14,547 m³ of leachate will be generated in a 3 month period. Compared to an average tankered leachate volume of 12,821 m³ during the same period, this shows that leachate generation exceeds the current tankered quantities. During a period of



heavy rainfall, leachate generation can increase to 36,528 m³ over a 3 month period which is more than double the average amount currently tankered.

The total capacity of the three storage tanks is 162 m³. Based on the average water balance estimate a total of 161.6 m³ of leachate is produced per day. Although the size of the leachate tanks is consistent with the amount of leachate predicted to be generated, this is during average conditions. Whilst it is likely that during summer periods capacity is adequate so long as the tanks are emptied daily, during the winter months the amount produced per day is likely to be greater. In a period of high rainfall, as observed between November 2009 and January 2010, approximately 407 m³ per day could be generated. Tankering typically ceases for 1 ½ days during a week and therefore under these conditions approximately 611 m³ of leachate would require storage during this time. Under wetter conditions close management of tankering would be required during the remaining 5 ½ days to keep up with the amount of leachate generated but even with this it is likely that the storage would be inadequate for night time generation. It is concluded that there is currently insufficient storage capacity to store the amount of leachate generated, particularly under wetter than average conditions.

4.1.2 Effectiveness of Leachate Management in Phase 1

Two wells are pumped in Phase 1 Cells 1 to 10 and 12 (wells LD3 and SW Sump), totalling an approximate pumping volume of 61.5 m³ in a 3 month period. The estimated leachate generation rates for Phase 1 Cells 1 to 10 and 12 are high compared to this leachate abstraction volume, which could in part explain why leachate levels are steadily increasing in this part of Phase 1. Leachate levels in LW1 and LW2 are consistently above the compliance level of 1 m above the cell basal liner. In these cells the abstraction points for Cells 1 to 10 and 12 are from a leachate drain located around the eastern and western boundary of the cells and therefore leachate is unlikely to be removed evenly from across the cell area. It is possible that removing leachate from the perimeter leachate drain does not have sufficient influence on the area where monitoring wells LW1, LW2 and LW4 are located such that leachate levels cannot be adequately reduced to below compliance levels in these wells. It is evident from the Drawing 501/2 that leachate levels are higher in the centre of Cells 1 to 10 and 12 and that there are potentially components of flow to the north towards Cells 11, 14 and 15 as well as to the south and east towards the leachate drain. The low pumped volumes, along with the distribution of leachate levels across the cell, suggest that the leachate extraction system in Cells 1 to 10 and 12 requires improvement.

Predicted leachate generation rates in Phase 1 Cells 11, 13, 14 and 15 are relatively low; under average conditions a total of 1,045 m³ in a 3 month period, which is less than one tenth of the total leachate generation for the Site. Assuming that all of the remaining pumps installed at the Site (eight excluding the pumps in SW Sump and LD3 for which pumping rates are known) pump at the same rate, based on the estimated annual volume of 28,909 m³, approximately 896 m³ of leachate is pumped from each well during an average 3 month period. Assuming the pumps in Cells 11, 13, 14 and 15 are at least as effective as the average, the abstraction rates required in these cells should be achievable by use of the existing pumping system even in wetter conditions. Hydrographs for these cells show that, with the pumping rates during the second part of 2010 supplemented with vacuum tankering when required, leachate levels can be maintained at compliant levels.

4.1.3 Effectiveness of Leachate Management in Phase 2

The water balance predicts that, particularly during wetter periods (based on data from November 2009 to January 2010), it is likely that higher rates of leachate are generated in Phase 2 compared to the rate of removal. However, for the cells in Phase 2, hydrographs show that leachate levels have been compliant during 2010, demonstrating that the abstraction of leachate using the pumping system and vacuum tanker has been adequate. It is unlikely given the engineering of these cells that the yield from the wells would be a limiting factor and it is therefore considered likely that the infrastructure is effective but that leachate abstraction rates may require increasing during times of high rainfall. Should these cells be permanently capped, the water balance predicts that leachate generation would drop considerably to approximately half of the 'average scenario', such that as little as 46.7 m³ of leachate could be generated per day in Phase 2.



5.0 PROPOSED LEACHATE MANAGEMENT STRATEGY FOR PHASE 1 CELLS 1 TO 10 AND 12 TO ADDRESS IMPROVEMENT CONDITION 2A

The water balance predicts that under average conditions approximately 3,085 m³ of leachate is generated during a 3 month period in Cells 1 to 10 and 12. Records of pump abstraction volumes however indicate actual abstraction rates of only 61.5 m³ in a 3 month period from the leachate drain. Furthermore leachate level data suggests that the leachate drain is unlikely to be removing leachate evenly from across the cell area. It is therefore considered appropriate that a well field is installed across Cells 1 to 10 and 12 to allow more even extraction of leachate across the area. These would also provide a more robust leachate level and quality monitoring infrastructure.

Cells 1 to 10 and 12 are unlined and therefore it is inappropriate to assess compliance within the cells using a leachate compliance head or elevation. In unlined cells a higher leachate head indicates that less leakage is occurring through the base, and would therefore be considered more favourable than if a low, or no, leachate head were present.

For this reason it is considered most appropriate to assign a compliance criterion based on a leachate abstraction volume. Assuming that the remaining capping of Cells 1 to 10 and 12 is completed by the end of 2011, the water balance suggests that 3836 m³/yr of leachate will be generated in the future in this part of Phase 1. The HRA (Golder, 2008b) has concluded that in order to be protective of Rudbaxton Water, particularly with respect to ammoniacal nitrogen concentrations, a proportion of this total leachate generated (corresponding to 10 mm/yr of infiltration) requires removal from the Site. Based upon a surface area of 1.278 hectares, 1,278 m³ should therefore be extracted per year. It is proposed at this stage to retro-fit six wells, which would mean an average abstraction rate of 0.024 m³/hr from each well would be required. This is considered realistic, providing the wells are of sufficient diameter. Once installed, it is proposed to perform pump tests on these wells to determine whether sufficient yield can be obtained from the six wells or whether further are required to meet the compliance volume.

6.0 RECOMMENDATIONS

Based on the findings of the assessment the following recommendations are made:

- The storage capacity of the leachate storage tanks should be increased to allow sufficient capacity for leachate generation particularly under wetter conditions. The required storage will depend upon the future development of the Site and the proposed capping timetable. For example, permanent capping during 2012 is expected to reduce leachate generation rates; and
- Improvements to the leachate management infrastructure in Cells 1 to 10 and 12 should be made as detailed in Section 5.0. Six retro-fitted wells should be installed, and tested to determine their ability to remove the required leachate from across the cells to maintain compliance.

7.0 REFERENCES

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Report Signature Page

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DRAWINGS

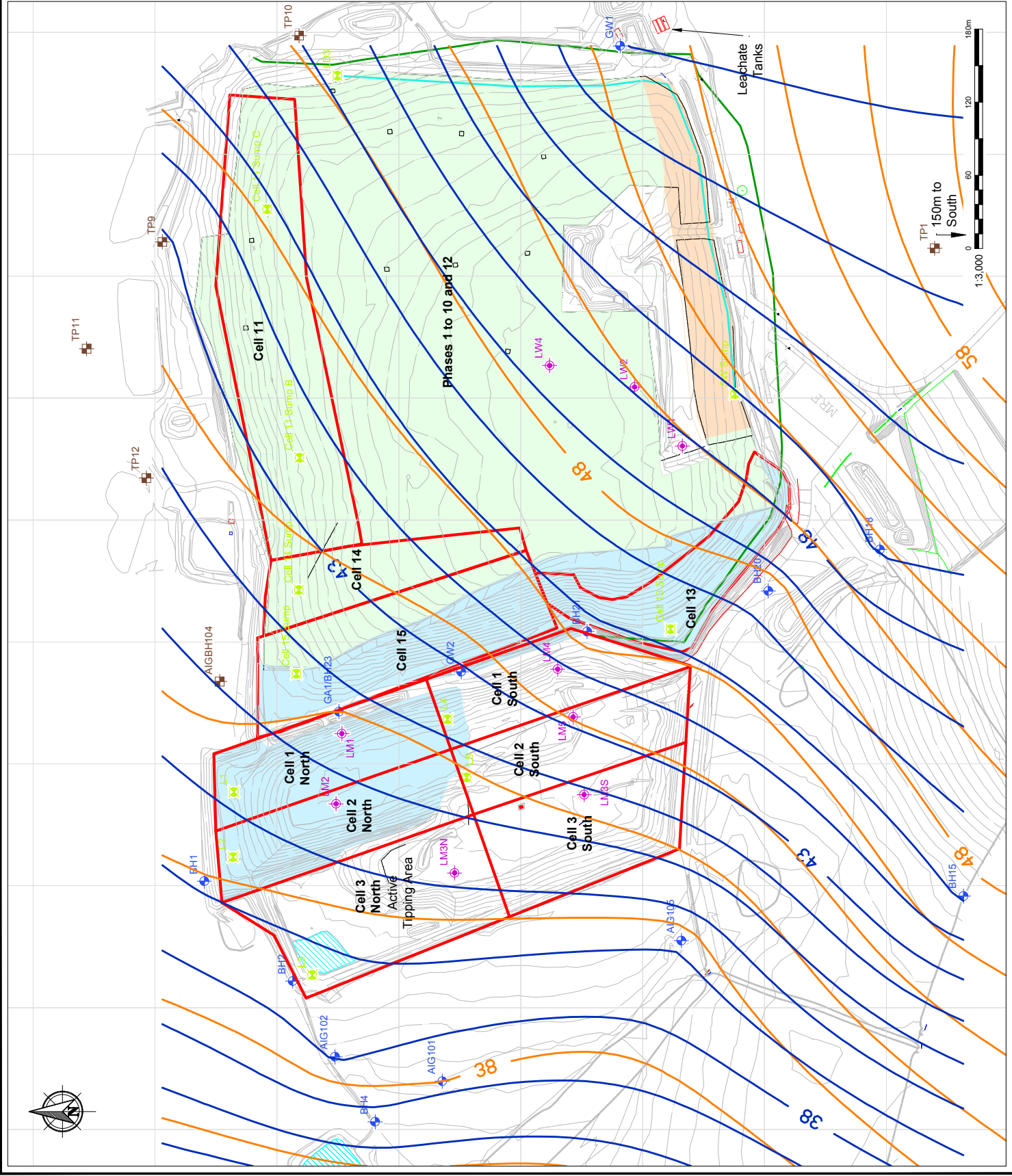
Drawing 501/1 Site Layout Plan

Drawing 501/2 Leachate Levels across Phase 1



Legend

- Groundwater monitoring borehole
- Leachate monitoring well
- Leachate sump
- Trial pit
- Groundwater cut off wall
- Approximate extent of existing geomembrane / clay capping
- Approximate extent of clay capping
- Temporary capping
- Groundwater contours August 2010
- Groundwater contours December 2010
- Leachate drain

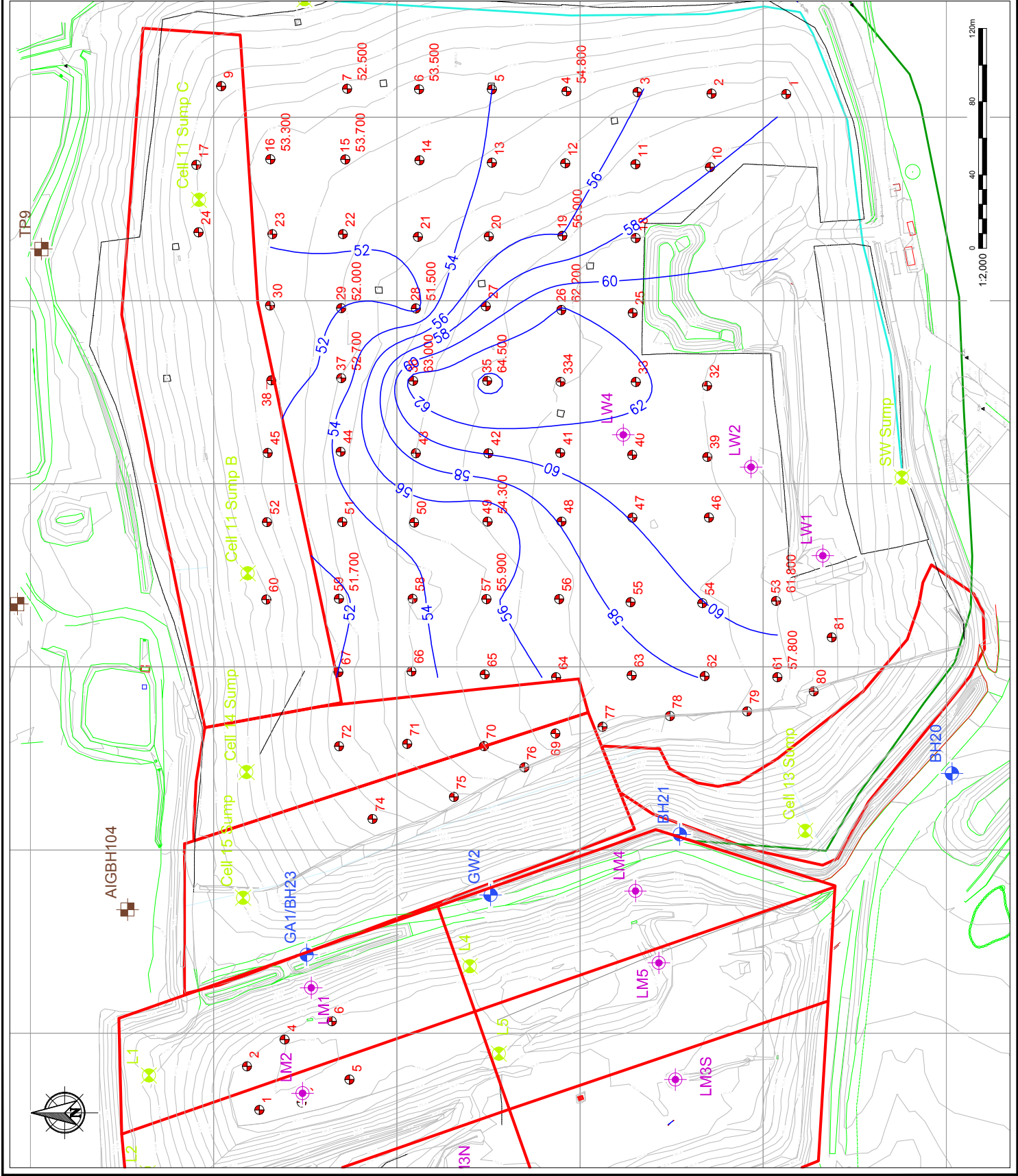


Notes

1. Base survey provided by Sita, Drawing Ref whg_CA_1210, dated December 2010.
2. Cell locations from RML supplied drawings.

Client	Sita UK Limited		
Project	Withyhedge Landfill		
Title	Leachate Management Review		
Created by	AB	Requested by	NC
Reviewed by	DD	Project No.	11514290005
File No.	5232913	Status	Issue
Scale	1:3,000	Rev	-
Drawing No.	501/1		

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Legend

- Groundwater monitoring borehole
- Leachate monitoring well
- Leachate sump
- Trial pit
- Groundwater cut off wall
- Leachate drain
- Gas Wells
- Gas Well Number
- Leachate level (m AOD)
- Leachate level contours September 2010 to May 2011 (m AOD) in Phase 1
- Cells 1 to 10 and 12

Notes

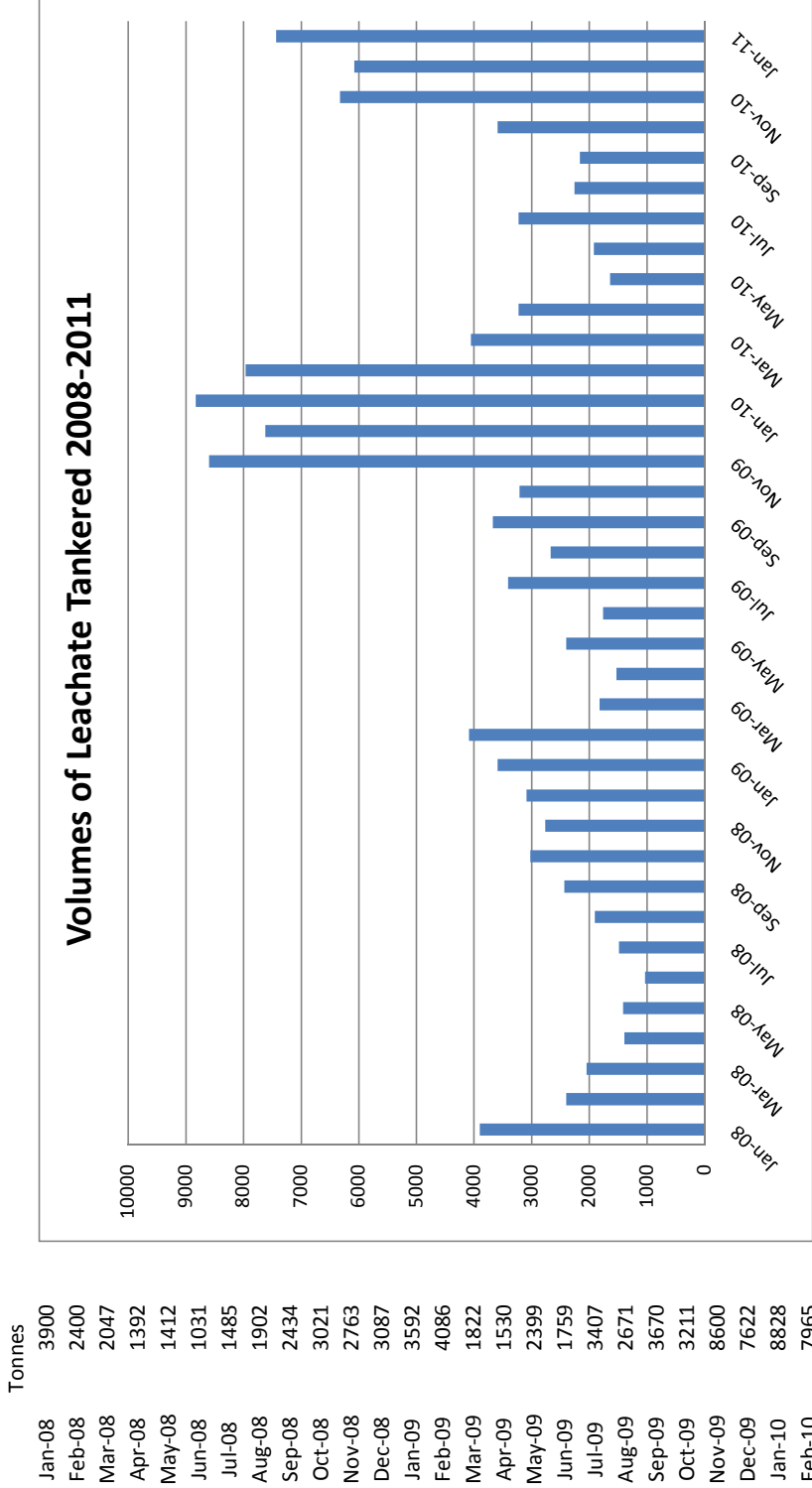
1. Base survey provided by Sita. Drawing Ref whg_CA_1210, dated December 2010.
2. Cell locations from RML supplied drawings. SNABS-PS003, dated March 2009.
3. Gas Wells taken from Drawing

Client	Sita UK Limited				
Project	Withyhedge Landfill				
Title	Leachate Management Review				
	Leachate Levels Across Phase 1 Cells 1 to 10 and 12				
Created by	AB	NC	DRVJ	DD	21/07/11
File No.	5233257		Project No.	11514290005	
Scale	A3		Scale	1:3,000	
Drawing No.	A3		Issue		Rev
	501/2				
	-				



APPENDIX 501/1

Leachate Disposal Volumes

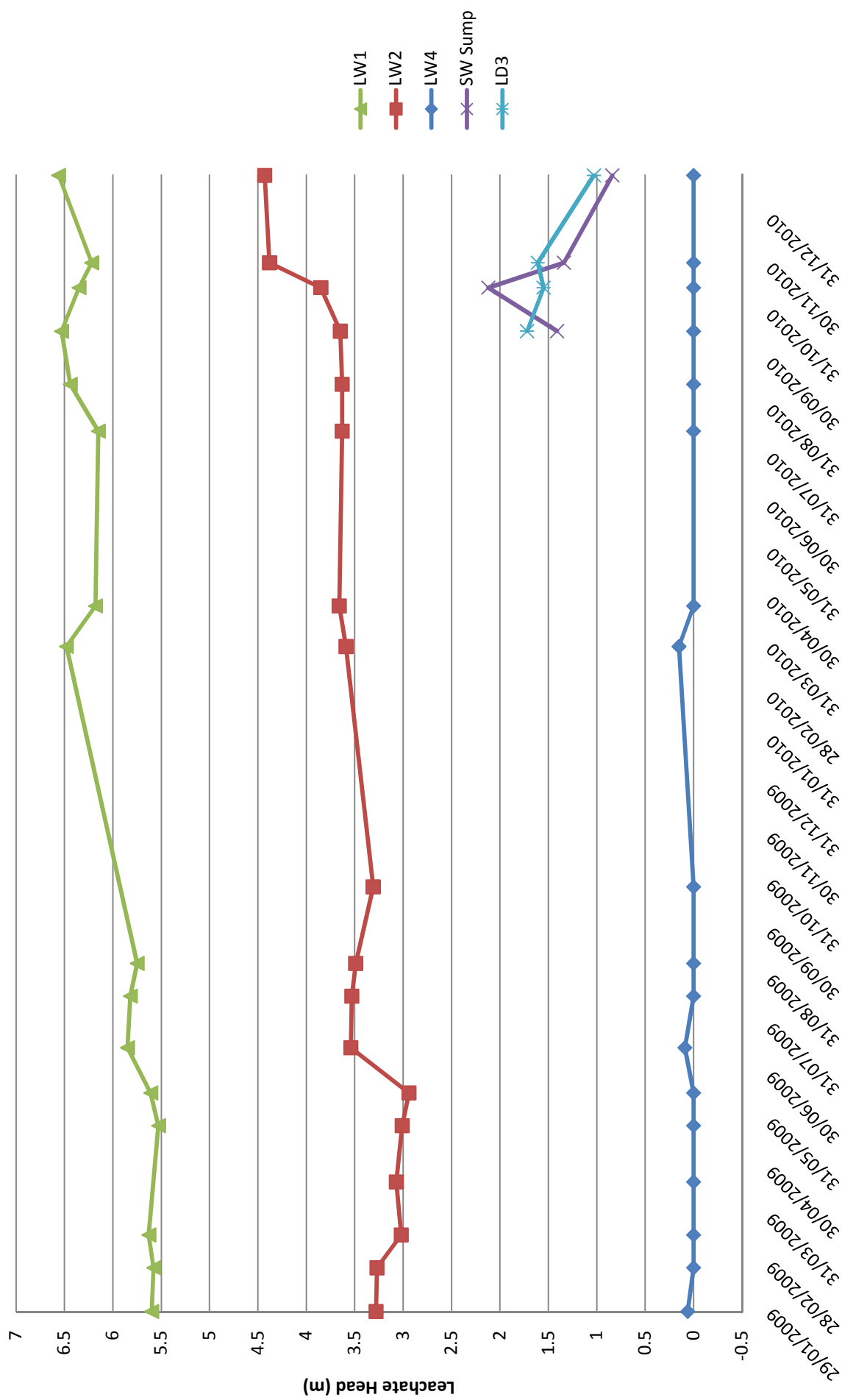




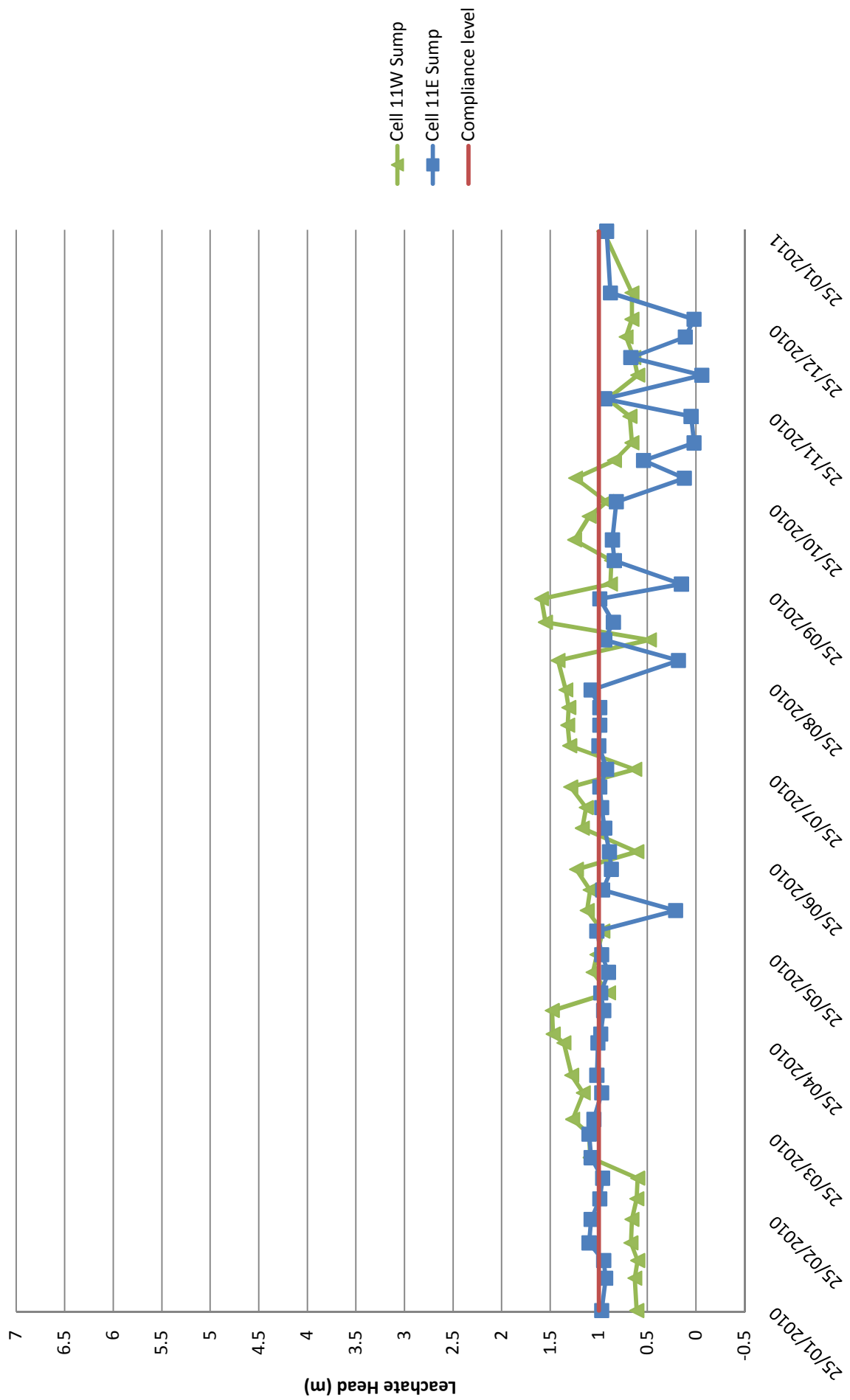
APPENDIX 501/2

Leachate Level Hydrographs

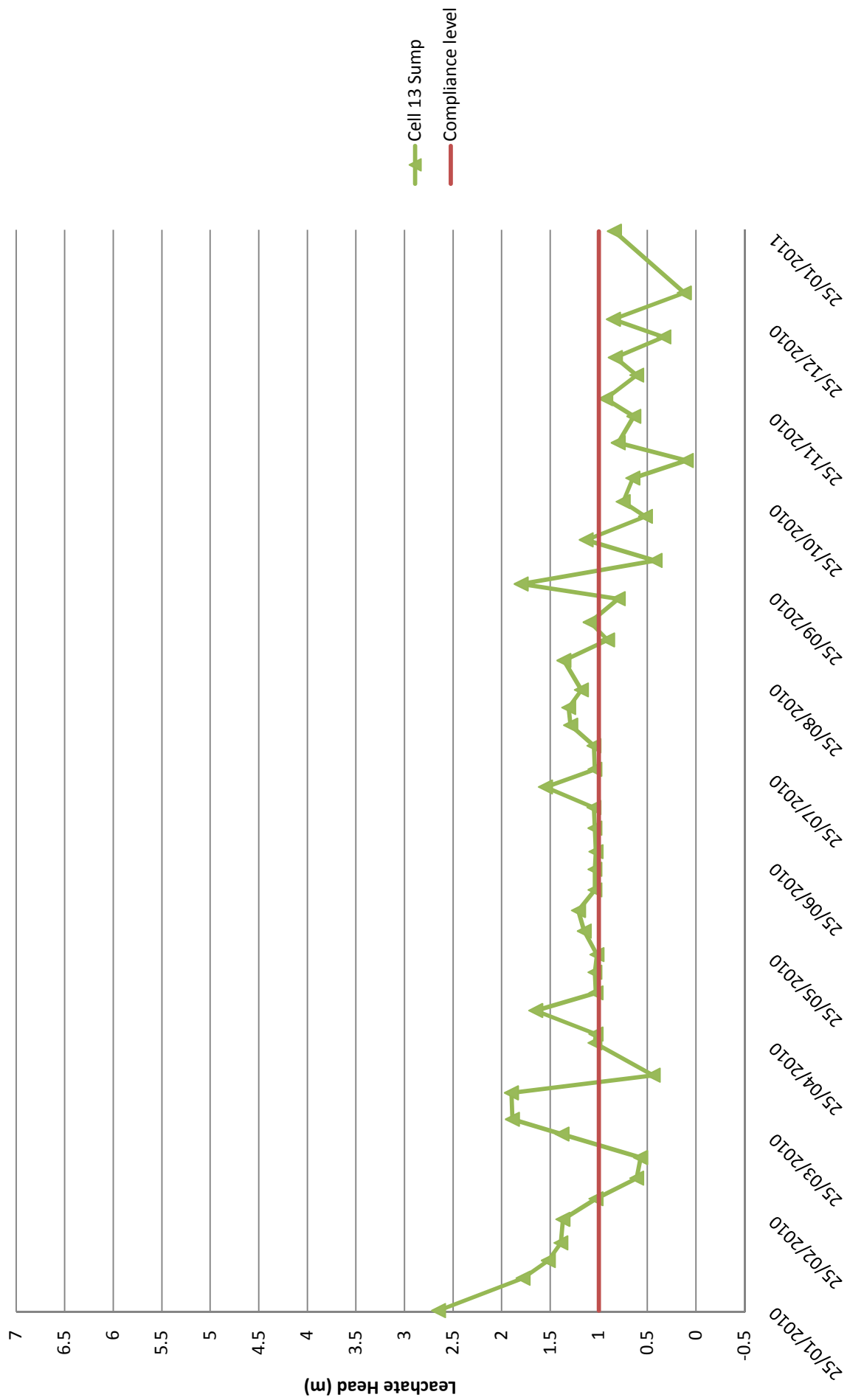
Leachate Heads - Phase 1 - Cells 1 to 10 and 12



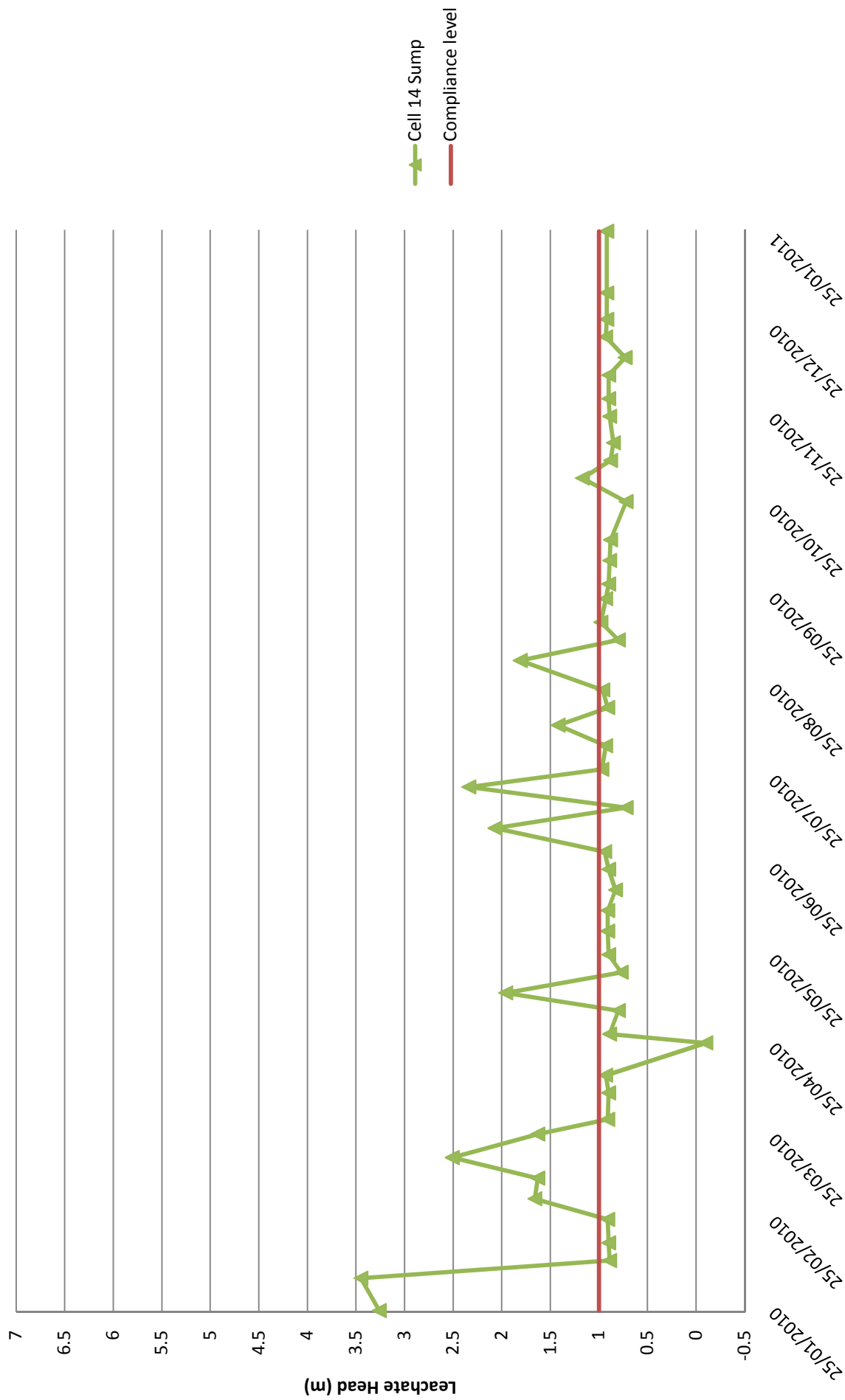
Leachate Heads - Phase 1 - Cell 11



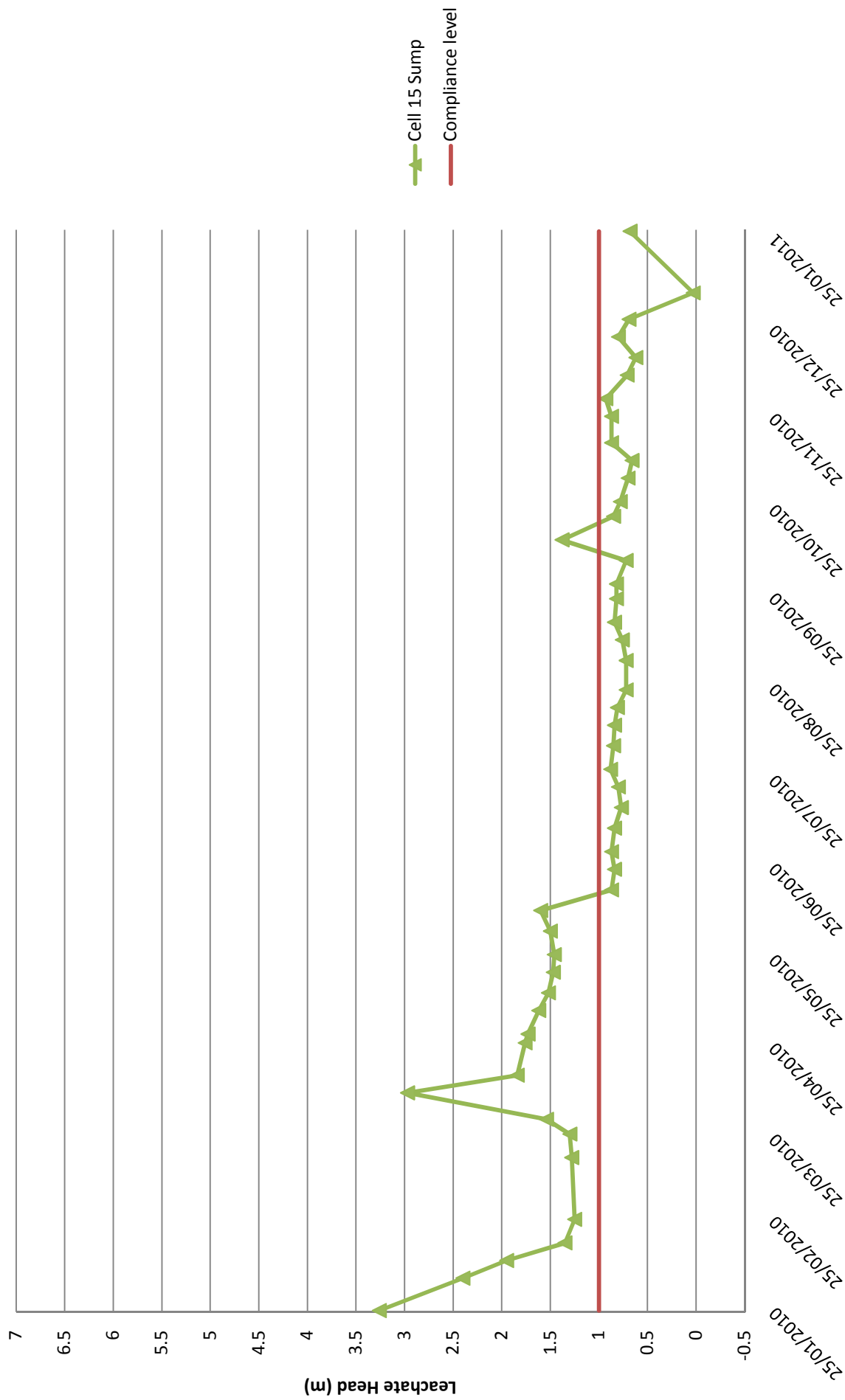
Leachate Heads - Phase 1 - Cell 13



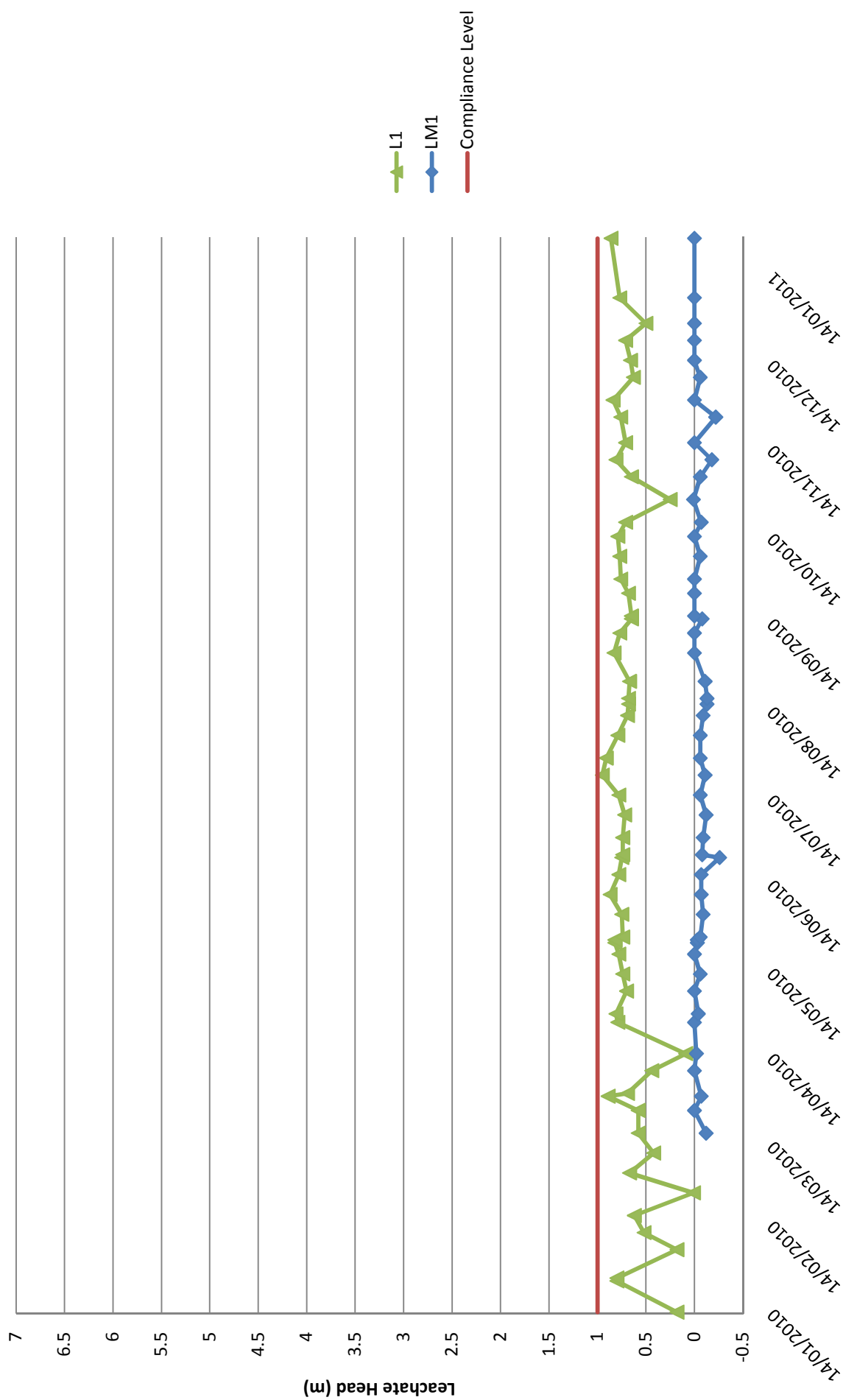
Leachate Heads - Phase 1 - Cell 14



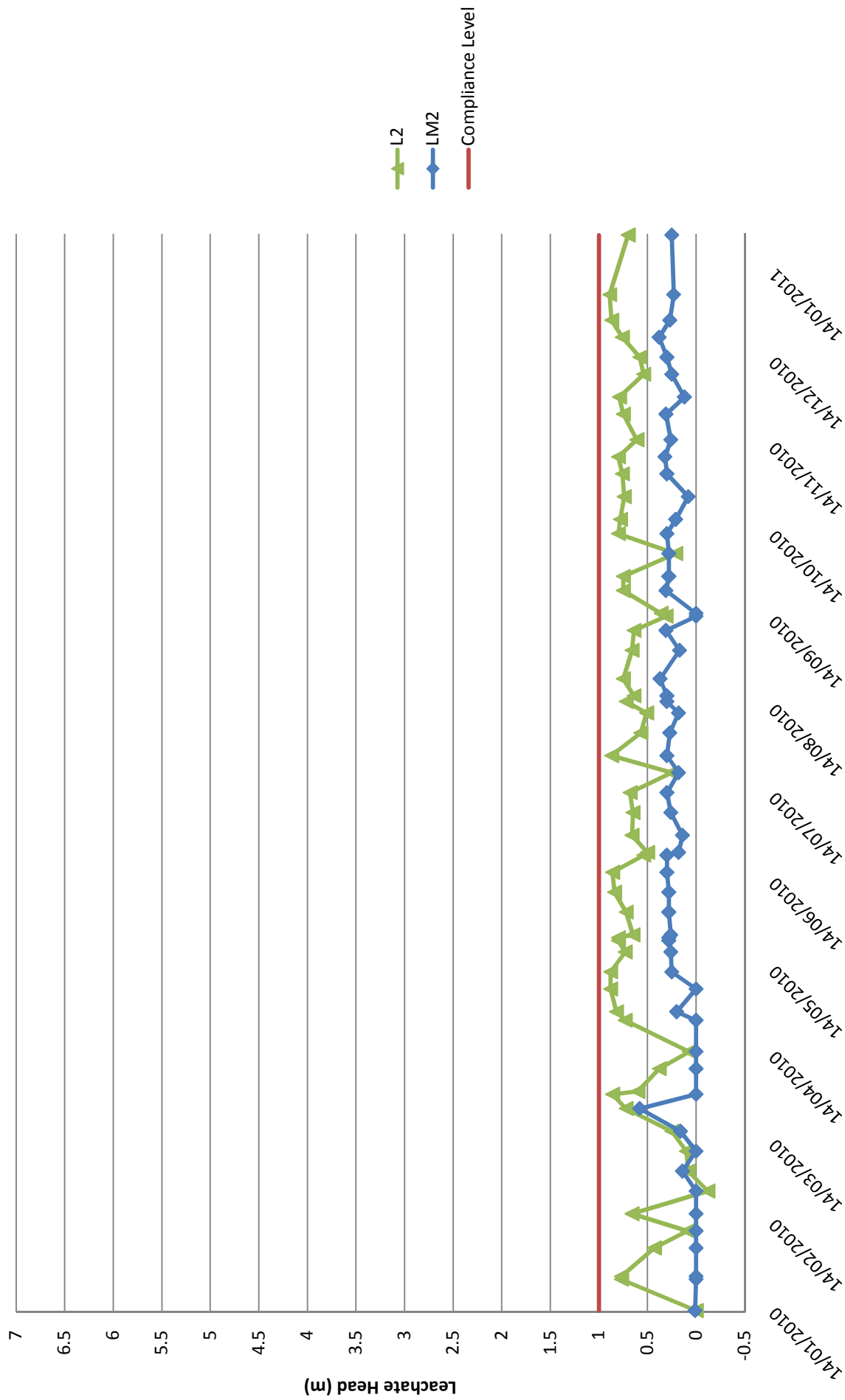
Leachate Heads - Phase 1 - Cell 15



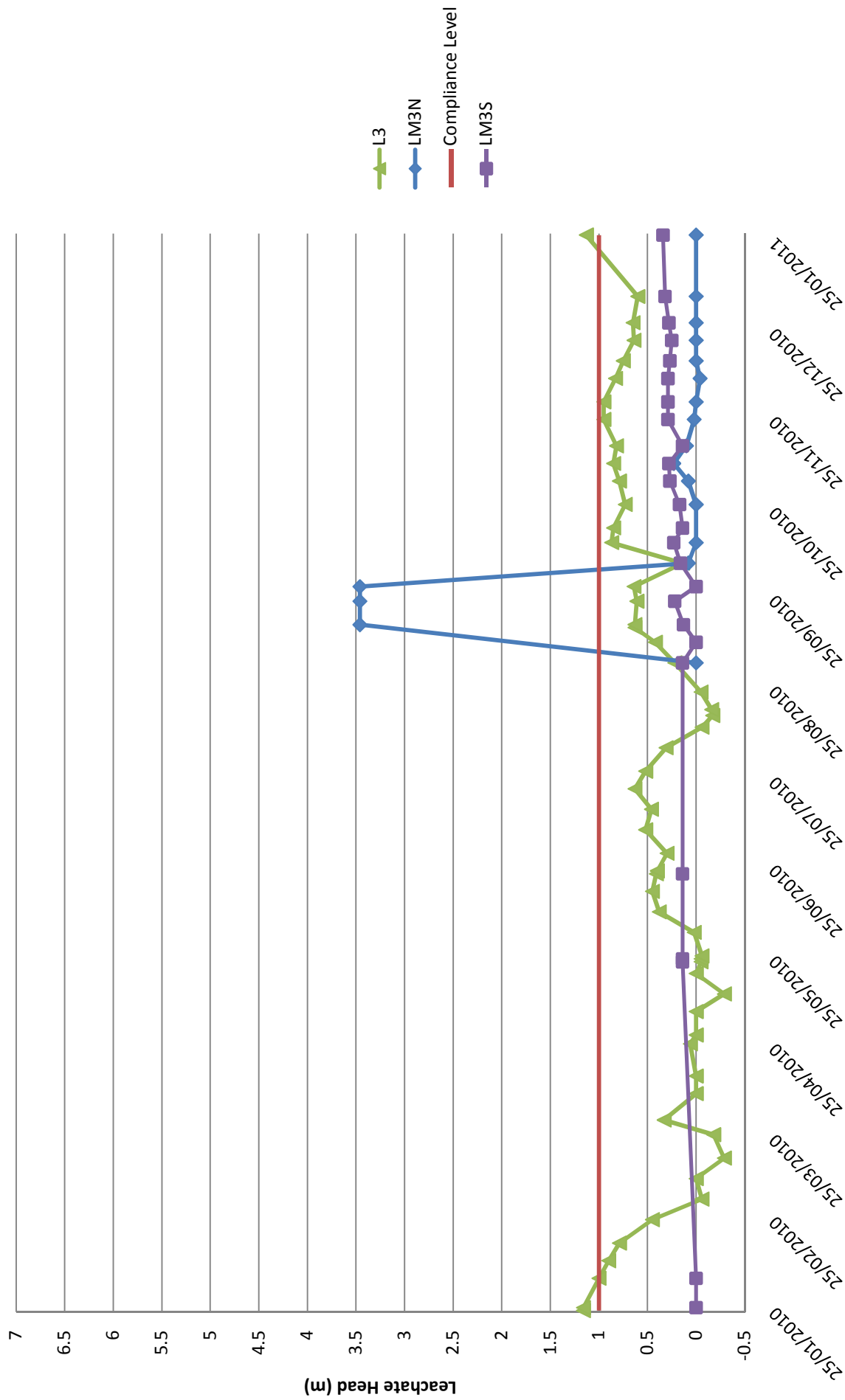
Leachate Heads - Phase 2 - Cell 1 North



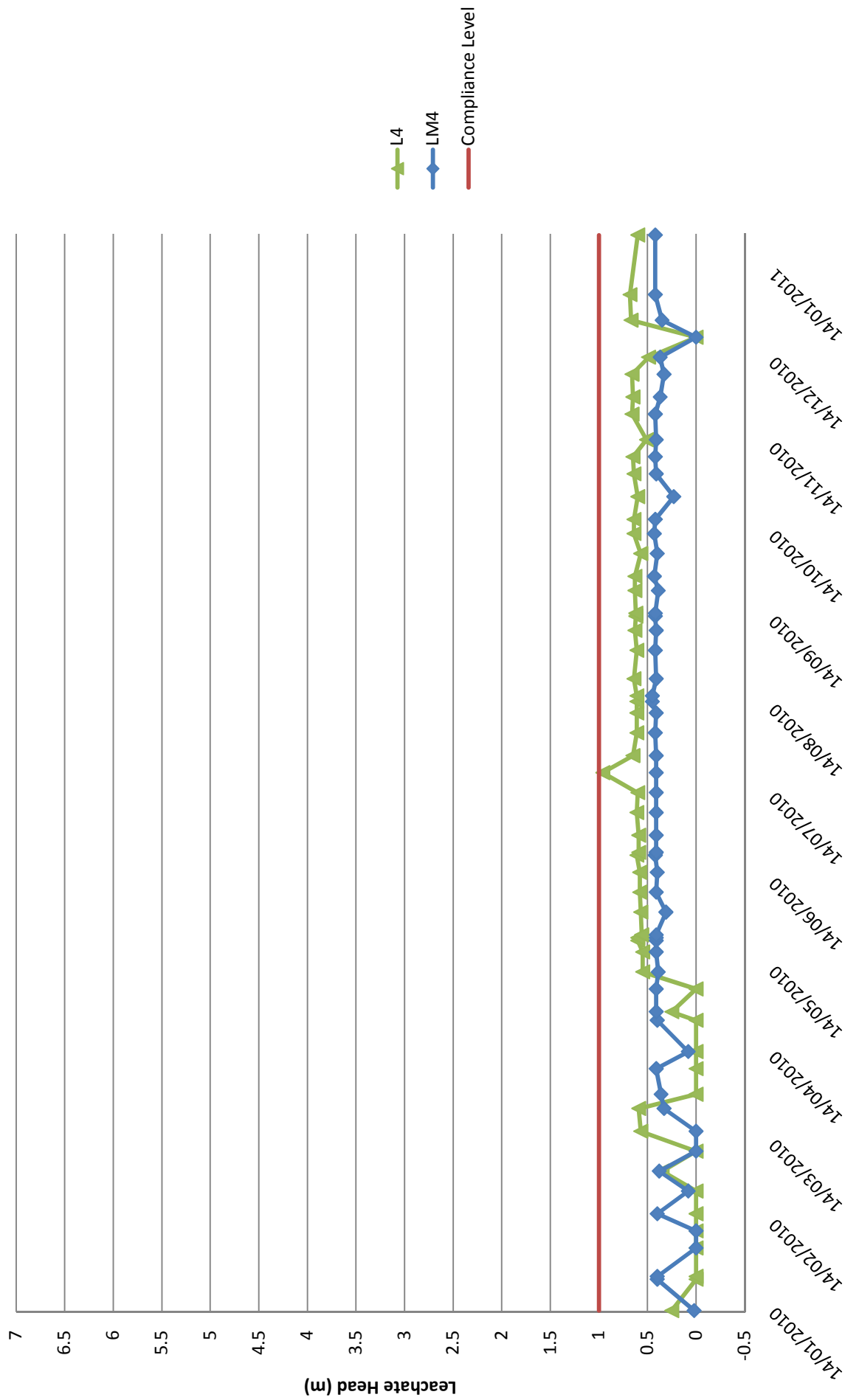
Leachate Heads - Phase 2 - Cell 1 South



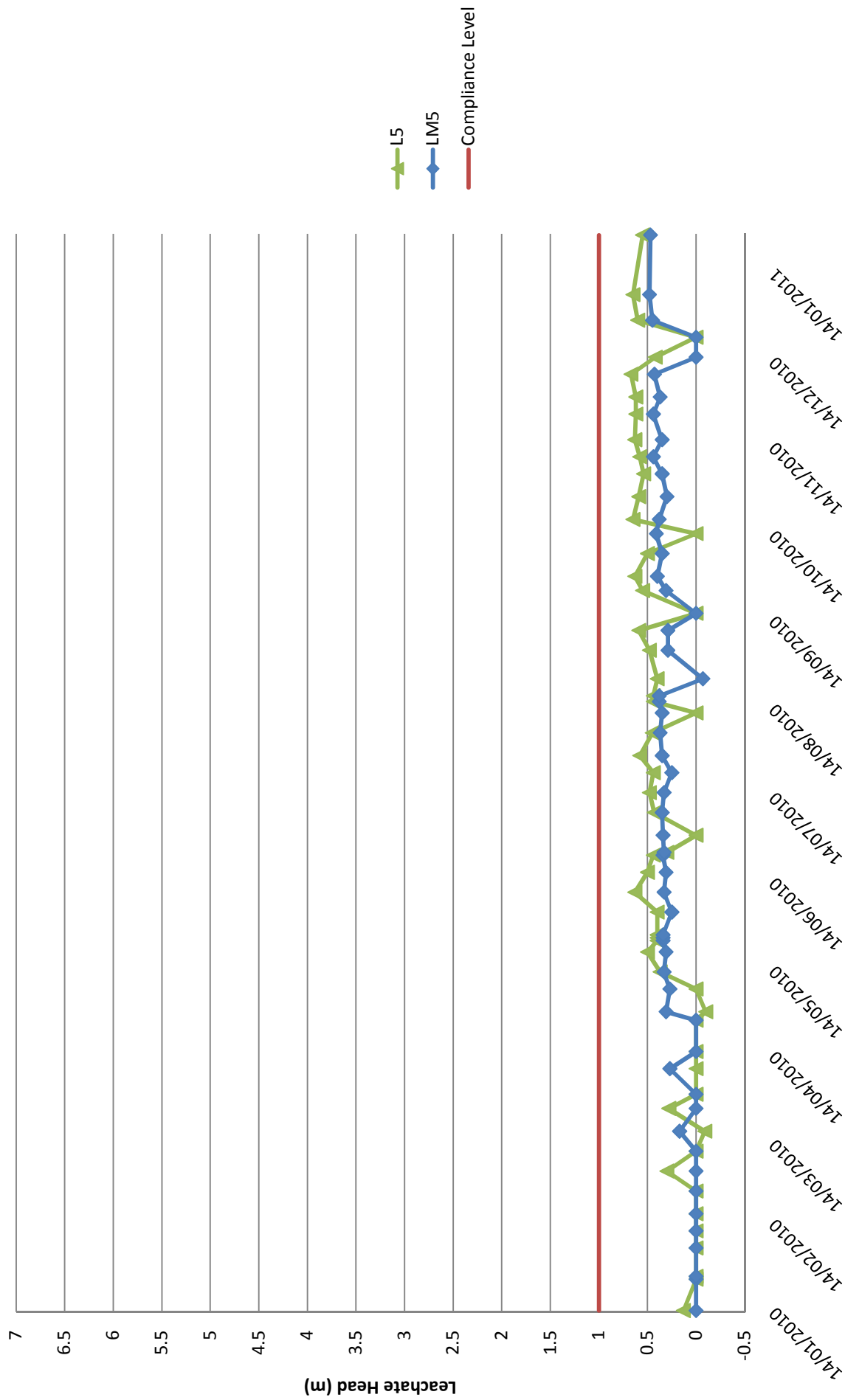
Leachate Heads - Phase 2 - Cell 3



Leachate Heads - Phase 2 - Cell 1 South



Leachate Heads - Phase 2 - Cell 2 South

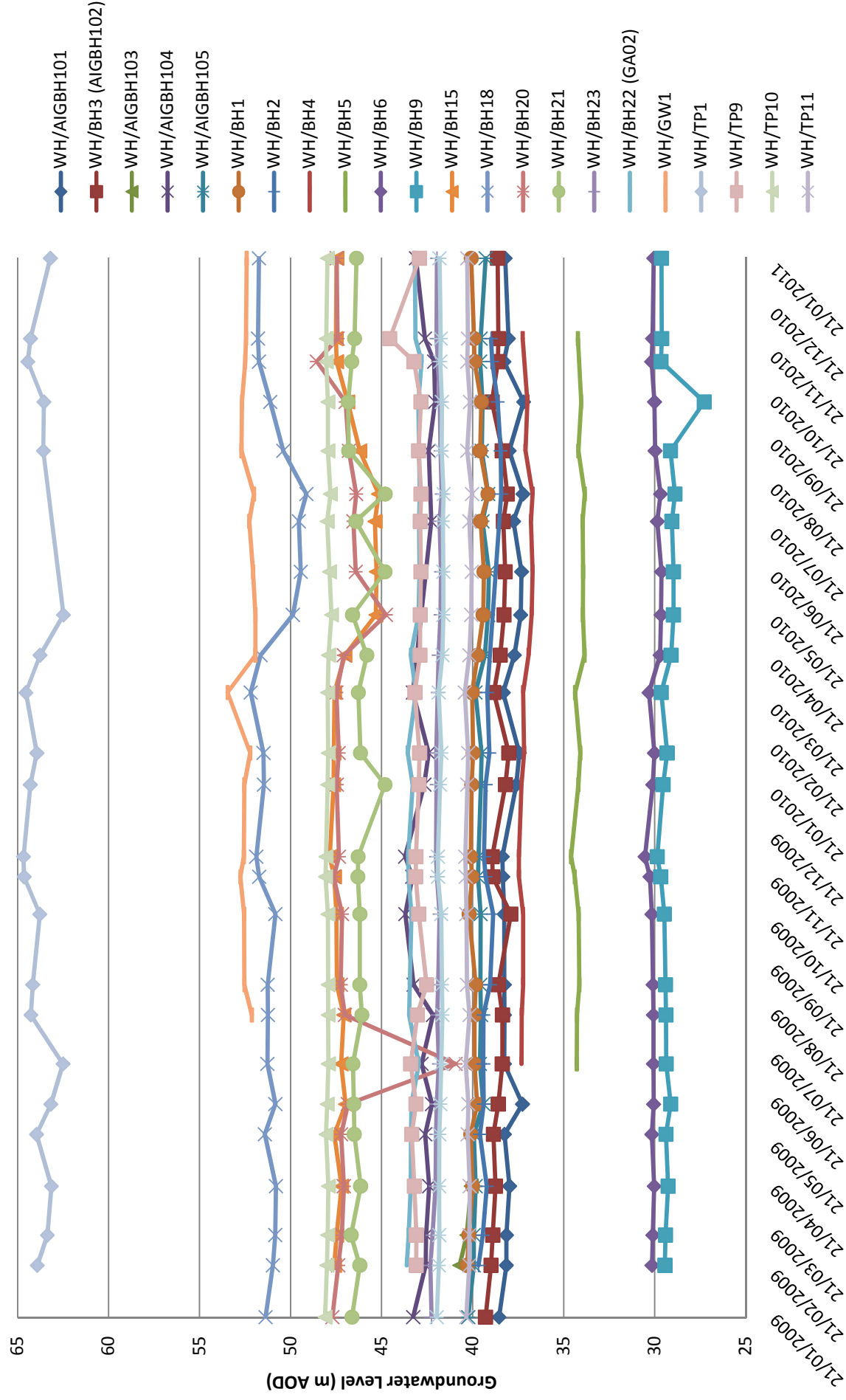




APPENDIX 501/3

Groundwater Level Hydrographs

Groundwater Levels January 2009 to January 2011





APPENDIX 501/4

Water Balance

Water Balance- Average 3 month period

Parameter	Units	Value	Source of Data
Rainfall	m/3 months		0.2855 Site Rainfall Data provided by SITA
Evaporation	m/3 months		0.12825 MAFF, 1976 for Area 50
Infiltration to open waste	m/3 months		0.165 Calculated effective rainfall from rainfall and evaporation data
Infiltration through temp cap	m/3 months		0.0375 Golder Judgement
Infiltration through permanent cap	m/3 months		0.0075 Golder Judgement based on HDPE membrane cap
Drainable porosity	fraction by volume		0.046 Knox, 2006
Leachate compliance level	m		1 Specified in WML/Permit

Prepared by: Nicola Croft
Date: 24-Feb-11
Reviewed by: David Drury
Date: 01-Mar-11

		Phase 1							Phase 2		
Calculation of Infiltration to Cells		Cells 1-10,12	Cell 11	Cell 13	Cell 14	Cell 15	Cells 1 and 2 North	Cells 1 and 2 South	Cell 3 South	Cell 3 North	
Basal Area	m2	91110	9170	6200	5540	12610	17030	14590	11860	13350	
Surface Area	m2	127820	26000	8670	8000	17280	26170	18820	15660	17670	
Area no waste	m2	0	0	0	0	0	0	0	0	6890	
Area open waste	m2	13500	0	0	0	0	0	18820	15660	10780	
Area temporary capped	m2	0	0	8670	0	11188	26170	0	0	0	
Area permanently capped	m2	114320	26000	0	8000	6092	0	0	0	0	
Runoff from open liner	m3	0	0	0	0	0	0	0	0	1967	
Infiltration to open waste	m3	2228	0	0	0	0	0	3105	2584	1779	
Infiltration-temporary cap	m3	0	0	325	0	420	981	0	0	0	
Infiltration-permanent cap	m3	857	195	0	60	46	0	0	0	0	
Total volume of water entering cell during 3 month period	m3	3085	195	325	60	465	981	3105	2584	3746	
		TOTAL							TOTAL		14547

Storage of leachate											
Amount of leachate in storage at compliance level		4191.1	421.8	285.2	254.8	580.1	783.4	671.1	545.56	614.1	
									TOTAL		8347.2

Water Balance- Wet 3 month period

Parameter	Units	Value	Source of Data
Rainfall	m/3 months		0.525 Site Rainfall Data provided by SITA- Nov 2009-Jan 2010
Evaporation	m/3 months		0.014 MAFF, 1976 for Area 50 for Nov-Jan
Infiltration to open waste	m/3 months		0.511 Calculated effective rainfall from rainfall and evaporation data
Infiltration through temp cap	m/3 months		0.0375 Golder Judgement
Infiltration through permanent cap	m/3 months		0.0075 Golder Judgement based on HDPE membrane cap
Drainable porosity	fraction		0.046 Knox, 2006
Leachate compliance level	m		1 Specified in WML/Permit

Prepared by: Nicola Croft
Date: 24-Feb-11
Reviewed by: David Drury
Date: 01-Mar-11

Calculation of Infiltration to Cells	Phase 1							Phase 2		
	Cells 1-10,12	Cell 11	Cell 13	Cell 14	Cell 15	Cells 1 and 2 North	Cells 1 and 2 South	Cell 3 South	Cell 3 North	
Basal Area	91110	9170	6200	5540	12610	17030	14590	11860	13350	
Surface Area	127820	26000	8670	8000	17280	26170	18820	15660	17670	
Area no waste	0	0	0	0	0	0	0	0	6890	
Area open waste	13500	0	0	0	0	0	18820	15660	10780	
Area temporary capped	0	0	8670	0	11188	26170	0	0	0	
Area permanently capped	114320	26000	0	8000	6092	0	0	0	0	
Runoff from open liner	0	0	0	0	0	0	0	0	3617	
Infiltration to open waste	6899	0	0	0	0	0	9617	8002	5509	
Infiltration-temporary cap	0	0	325	0	420	981	0	0	0	
Infiltration-permanent cap	857	195	0	60	46	0	0	0	0	
Total volume of water entering cell during 3 month period	7756	195	325	60	465	981	9617	8002	9126	
								TOTAL	36528	

Storage of leachate										
Amount of leachate in storage at compliance level	4191.1	421.8	285.2	254.8	580.1	783.4	671.1	545.56	614.1	
								TOTAL	8347.2	

<i>Parameter</i>	<i>Units</i>	<i>Value</i>	<i>Source of Data</i>
Rainfall	m/3 months	0.2855	Site Rainfall Data provided by SITA
Evaporation	m/3 months	0.12825	MAFF, 1976 for Area 50
Infiltration to open waste	m/3 months	0.165	Calculated effective rainfall from rainfall and evaporation data
Infiltration through temp cap	m/3 months	0.0375	Golden Judgement
Infiltration through permanent cap	m/3 months	0.0075	Golden Judgement based on HDPE membrane cap
Drainable porosity	fraction	0.046	Knox, 2006
Leachate compliance level	m	1 Specified in WML/Permit	

Nicola Croft
24-Feb-11
David Drury
01-Mar-11

[illegible][illegible]

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Appendix B

Parameter	Units	Value	Source
Rainfall	m / 3 months	0.2855	Site Rainfall
Evaporation	m / 3 months	0.12825	MAFF 1976 for Area 50
Infiltration to Open Waste	m / 3 months	0.165	Calculated effective Rainfall (see Golders Justification 2011)
Infiltration through temp cap	m / 3 months	0.0375	(Golders Justification) - not changed
Infiltration through perm cap	m / 3 months	0.0075	(Golders Justification) - not changed
Drainable Porosity	fraction by volume	0.046	Knox 2006 - not changed
Leachate compliance level	m / 3 months	1	Specified in Permit

Units	Calculation of Infiltration	Phase 1				
		Cells 1-10, 12	Cell 11	Cell 13	Cell 14	Cell 15
m2	Base Area	91110	9170	6200	5540	12610
m2	Surface Area	127820	26000	8760	8000	17280
m2	Area No Waste	0	0	0	0	0
m2	Area Open Waste	0	0	0	0	0
m2	Area Temp Capped	0	0	4000	0	0
m2	Area Perm Capped	127820	26000	4760	8000	17280
m3	Run-off from Open Liner	0	0	0	0	0
m3	Infiltration to open waste	0	0	0	0	0
m3	Infiltration to Temp Cap	0	0	150	0	0
m3	Infiltration to Perm Cap	959	195	35.7	60	130
m3	TOTAL Vol entering cell during 3 month period	959	195	186	60	130

Phase 2							
Cell 1 and 2 North	Cell 1 and 2 South	Cell 3 South	Cell 3 North	Valley Cells	Cell 4North	Cell 5 North	Cell 5 and 4 South
17030	14590	11860	13350	6500	13148	5031	9601
26170	18820	15660	17670	30000	17400	10760	0
0	0	0	0	0	0	0	9601
0	0	0	0	0	17400	10760	0
13000	12000	10000	8000	16000	0	0	0
13170	6820	5660	9670	14000	0	0	0
0	0	0	0	0	0	0	2741
0	0	0	0	0	2871	1775	0
488	450	375	300	600	0	0	0
99	51	42	73	105	0	0	0
586	501	417	373	705	2871	1775	2741
						TOTAL	11499

Parameter	Units	Value	Source
Rainfall	m / 3 months	0.2855	Site Rainfall
Evaporation	m / 3 months	0.12825	MAFF 1976 for Area 50
Infiltration to Open Waste	m / 3 months	0.165	Calculated effective Rainfall (see Golders Justification 2011)
Infiltration through temp cap	m / 3 months	0.0375	(Golders Justification) - not changed
Infiltration through perm cap	m / 3 months	0.0075	(Golders Justification) - not changed
Drainable Porosity	fraction by volume	0.046	Knox 2006 - not changed
Leachate compliance level	m / 3 months	1	Specified in Permit

Units	Calculation of Infiltration	Phase 1				
		Cells 1-10, 12	Cell 11	Cell 13	Cell 14	Cell 15
m2	Base Area	91110	9170	6200	5540	12610
m2	Surface Area	127820	26000	8760	8000	17280
m2	Area No Waste	0	0	0	0	0
m2	Area Open Waste	0	0	0	0	0
m2	Area Temp Capped	0	0	0	0	0
m2	Area Perm Capped	127820	26000	8760	8000	17280
m3	Run-off from Open Liner	0	0	0	0	0
m3	Infiltration to open waste	0	0	0	0	0
m3	Infiltration to Temp Cap	0	0	0	0	0
m3	Infiltration to Perm Cap	959	195	65.7	60	130
m3	TOTAL Vol entering cell during 3 month period	959	195	66	60	130

Phase 2							
Cell 1 and 2 North	Cell 1 and 2 South	Cell 3 South	Cell 3 North	Valley Cells	Cell 4North	Cell 5 North	Cell 5 and 4 South
17030	14590	11860	13350	6500	13148	5031	9601
26170	18820	15660	17670	30000	17400	10760	0
0	0	0	0	0	0	0	9601
0	0	0	0	0	0	5760	0
0	0	0	0	0	0	0	0
26170	18820	15660	17670	30000	17400	10760	0
0	0	0	0	0	0	0	2741
0	0	0	0	0	0	950	0
0	0	0	0	0	0	0	0
196	141	117	133	225	130.5	80.7	0
196	141	117	133	225	131	1031	2741
						TOTAL	6124

Parameter	Units	Value	Source
Rainfall	m / 3 months	0.525	Site Rainfall
Evaporation	m / 3 months	0.014	MAFF 1976 for Area 50
Infiltration to Open Waste	m / 3 months	0.511	Calculated effective Rainfall (see Golders Justification 2011)
Infiltration through temp cap	m / 3 months	0.0375	(Golders Justification) - not changed
Infiltration through perm cap	m / 3 months	0.0075	(Golders Justification) - not changed
Drainable Porosity	fraction by volume	0.046	Knox 2006 - not changed
Leachate compliance level	m / 3 months	1	Specified in Permit

Units	Calculation of Infiltration	Phase 1				
		Cells 1-10, 12	Cell 11	Cell 13	Cell 14	Cell 15
m2	Base Area	91110	9170	6200	5540	12610
m2	Surface Area	127820	26000	8760	8000	17280
m2	Area No Waste	0	0	0	0	0
m2	Area Open Waste	0	0	0	0	0
m2	Area Temp Capped	0	0	4000	0	0
m2	Area Perm Capped	127820	26000	4760	8000	17280
m3	Run-off from Open Liner	0	0	0	0	0
m3	Infiltration to open waste	0	0	0	0	0
m3	Infiltration to Temp Cap	0	0	150	0	0
m3	Infiltration to Perm Cap	959	195	35.7	60	130
m3	TOTAL Vol entering cell during 3 month period	959	195	186	60	130

Phase 2							
Cell 1 and 2 North	Cell 1 and 2 South	Cell 3 South	Cell 3 North	Valley Cells	Cell 4North	Cell 5 North	Cell 5 and 4 South
17030	14590	11860	13350	6500	13148	5031	9601
26170	18820	15660	17670	30000	17400	10760	0
0	0	0	0	0	0	0	9601
0	0	0	0	0	17400	10760	0
13000	12000	10000	8000	16000	0	0	0
13170	6820	5660	9670	14000	0	0	0
0	0	0	0	0	0	0	5041
0	0	0	0	0	8891	5498	0
488	450	375	300	600	0	0	0
99	51	42	73	105	0	0	0
586	501	417	373	705	8891	5498	5041
						TOTAL	23542

Appendix C

Withyhedge Landfill Site Gas Management Plan January 2014 V2



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APPENDICES

Appendix A SITA Power Procedures

SPCOS004	Hydrogen Sulphide CoSHH Data Sheet
SPHSP006	Personal Gas Alarms Procedure
SPOP003	Gas Field Balancing and Gas System Inspection Procedure
SPOP004	Drilling into Landfill Waste
SPOP005	Gas Well Setting Out Procedure
SPOP020	Prevention or Control of Sub-Surface Landfill Combustion
SPOP023	Procedure for Engineering & Construction Contracts
SPOP024	Instructions to Contractors Construction & Environmental
SPOP025	Instructions to Contractors Construction Quality Assurance
SPOP026	Engineering & Construction Contracts Health & Safety
SPOP027	Landfill Gas Development Procedure
SPOP028	Gas Utilisation and Flaring Systems
SPF054	Flow Diagram for Gas Pipes
SPF055	Dewatering Log



SPF056	Landfill Gas Development Rolling Programme
SPSWP015	Working with Hydrogen Sulphide
SPSWP016	Installation of LFG Collection Probes

Appendix B ENPL Procedures

ENPL Gas Balancing Protocol
Critical system failure
CAT 3516 Specification sheet
400kW Perkins (4008 series) Specification sheet
Booster / Flare Information
Sample of gas balance report
Sample of gas well condition survey

DRAWINGS

SITA Power Drawings and Standard Designs

SPSD005	SITA Power Boot Detail Drawing
SPSD005 Table	SITA Power Boot Detail Table
SPSD005A	SITA Power Leachate Tower Boot Detail Drawing
SPSD007	Spike wells construction
SPSD008	Horizontal Gas Well Design

ENPL Drawings and Standard Designs

SN103-4-WITHY-001 GCS	Gas Collection System Layout
NPL-4-103-002	Gas Utilisation Plant Layout
Gas Well and head ENPL 40-003-3	Standard Gas Well Head
ENPL- Boxed Manifold 09 Design	Manifold Box Design

1 INTRODUCTION

1.1 SITE BACKGROUND

Withyhedge Landfill Site is located approximately 5.5km north of Haverfordwest, Pembrokeshire at National Grid Reference SM 970 217. The site is classified as a non-hazardous landfill site. The site comprises of two phases known as Phases 1 and 2. Phase 1 is classified as a non – hazardous landfill but has historically accepted a restricted number of hazardous wastes including asbestos. Phase 2 is a non hazardous landfill.

Both phases were regulated under separate permits until a variation was issued on 16/09/10 which consolidated the two permits EPR/HP3498FS and EPR/BP3131SG. A notification of Permit Transfer from RML UK Limited to SITA UK Limited was issued on 18/02/11.

Following transfer a variation to permit EPR/GP3630HT was issued on 18/05/2011. This variation amongst other things enabled the waste types in the valley area to be changed from inert to non-hazardous.

The site is classified as a non-hazardous landfill that will accept a range of household, commercial and industrial wastes.

1.2 OVERVIEW OF CURRENT LANDFILL GAS MANAGEMENT

The landfill gas management system extracts landfill gas via 12 manifolds A to M.

The landfill has in the order of 103 No. 160mm diameter drilled landfill gas wells which are connected to the surface laid and buried manifolds via lengths of 63mm and 90mm pipe-work. The manifolds are connected via variable lengths of 180mm pipe-work into a 315mm carrier main.

The majority of the 103 permanent gas extraction wells installed at Withyhedge landfill are constructed of medium or high density polyethylene with an SDR of 11. This provides extra strength against the shear stresses experienced in a landfill environment.

The gas extraction wells have been drilled into the waste to varying depths depending on landfill conditions and stand-off requirements. The top section of the well is plain pipe with three metres of bentonite

providing the well seal. The rest of the well is perforated with slots to allow gas extraction. The annulus is filled with gravel.

All surface laid connection pipe-work is constructed of SDR 17.6 MDPE/HDPE pipe and gas wells are SDR 11 rated HDPE pipe.

Gas flows from the site via the carrier main to the gas control compound. The gas main is intercepted by a pumped knockout pot at the entrance to the compound. The gas extraction is expedited by a 2000M³/hr booster, which feeds a single 1136kW and a smaller 400kW spark ignition gas engines and a 2000M³/hr enclosed flare.

1.3 GAS MANAGEMENT PHILOSOPHY

As one of the leading waste management companies in the UK, SITA is dedicated to ensuring that landfill gas is controlled safely and effectively at all of its landfill sites.

This is achieved through the progressive capping of the site and the implementation of active gas management systems which collect, extract and treat landfill gas at sustainable levels to prevent pollution to the environment, harm to human health or detriment to the local community.

SITA is committed to maximising energy recovered from waste and to this end supports the landfill gas management hierarchy outlined in the Landfill Directive and adopted by Natural Resource Wales (NRW). This hierarchy places energy recovery from landfill gas at the top of the possible treatment options and SITA aims to implement landfill gas utilisation projects on all sites where it is deemed to be technically and financially viable.

Landfill gas management systems are designed to enable the collection, extraction and treatment of the maximum potential volume of landfill gas generated from a site. Implicit in this thinking, SITA will endeavour to ensure that its gas management systems ensure that the safe and sustainable extraction of landfill gas is maintained at all times, with the aim of preventing uncontrolled gas emissions. Please refer to the procedures set out in Appendix A.

All landfill gas management infrastructure and landfill gas management practices comply with relevant health and safety legislation.



SITA is committed to supporting the development of new landfill gas management technologies and will continue to operate in accordance with relevant regulations and codes.

SITA UK Ltd manages its activities through the use of a quality manual which includes an array of procedures. These procedures are reviewed and approved within SITA UK Ltd prior to inclusion in the quality process and are subject to periodic review. Improvements in gas management technique are copied across all SITA Power sites and accordingly Gas Management Plans share these procedures. The Annual Gas Management Plan Review specifically considers aspects of gas management which are specific to Withy hedge Landfill but also reviews the operation of standard procedures. This is a two way process enabling good practice to be imported into Withy hedge and/or transferred into other SITA UK Ltd sites.

1.4 MANAGEMENT STRUCTURE

1.4.1 SITA UK Limited

Management of the landfill gas extraction and control systems is the responsibility of the Landfill Site Manager who has responsibility for compliance with the Environmental Permit for the site.

When required, the Site Manager will call upon SITA Power to assist with particular technical issues relating to the gas management systems.

Day to day operation of the gas control system and routine balancing is carried out by ENER-G Natural Power Limited (ENPL) operators. The ENPL Operators on site are managed by the ENPL Operations Manager who works in accordance with this Gas Management Plan. The contractual and technical relationship with ENPL is primarily conducted by SITA Power Operations Manager.

SITA Power and their sub-contractor ENPL may also engage third parties to undertake specialist tasks such as engine maintenance, emissions testing and data collection works.

Effective gas control requires cooperation between all parties engaged in the management of the site. This gas management plan provides a formal framework and robust procedures to ensure complete gas control.

In general the salient site relationships are:

Site Manager:	Carries permit responsibility for the site. Manages all support services from landfill engineers, SITA Power
---------------	--



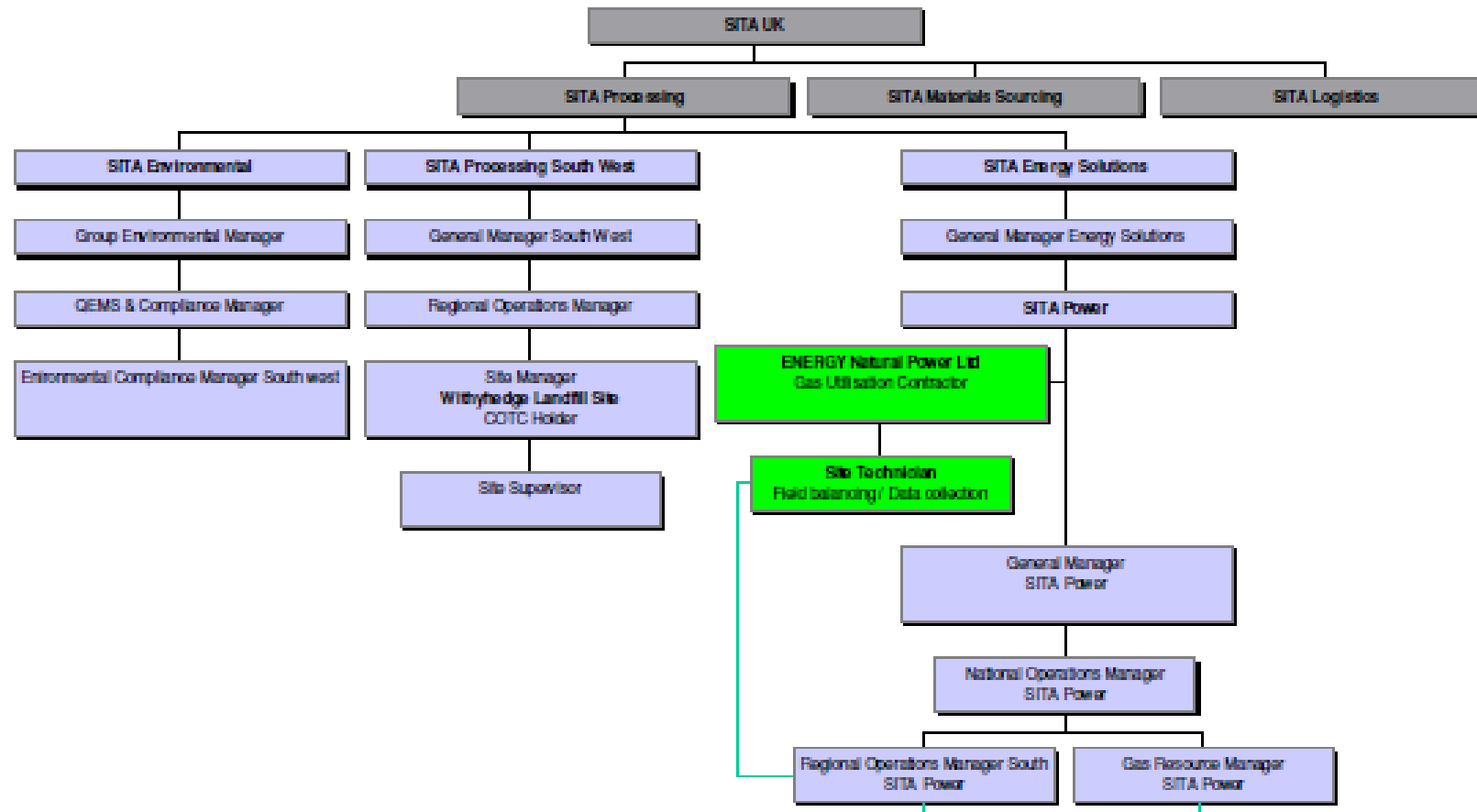
and compliance staff.

Landfill Engineer: Initiates design and construction of any improvements for leachate and landfill containment systems.

Compliance Manager: Provides an advice and support service to the Site Manager relating to all compliance issues.

SITA Power Operations Manager: Manages design, installation, operation and maintenance of all landfill gas control system through ENPL the landfill gas contractor.

An organogram of the SITA UK structure is included as follows:





1.4.2 SITA Power

SITA Power is responsible for all landfill gas power generation schemes within SITA UK Ltd. The primary aim of the landfill gas schemes is to ensure environmental compliance, with power generation through landfill gas utilisation being at the top of the hierarchy for treatment operations.

SITA Power's site activities are coordinated by the Regional Operations Manager.

1.4.3 ENER-G Natural Power Limited

The management and exploitation rights for landfill gas at Withyhedge are contracted to ENER-G Natural Power Limited (ENPL).

ENPL have extensive experience in the design management and operation of landfill gas systems and in the UK operate a portfolio of sites totalling 64MW generating capacity.

As a prudent and competent operator, ENPL have their own procedures for certain aspects of gas control. These procedures are subject to approval by SITA UK Ltd, acting to ensure that the PPC permit requirements are complied with and that Health & Safety issues are properly addressed.

These procedures are included in Appendix B.

At Withyhedge landfill, ENPL use their own specialist staff and contractors to manage gas control activities. ENPL understand and fully support the need to manage the Gas Control System (GCS) primarily for the purposes of environmental protection.

Care has been taken to ensure that ENPL and their sub-contractors are fully integrated into the site management team in particular with respect to odour management. This is done through site inductions and regular meetings with SITAs Operations Team.

2 OPERATIONS

In order to simplify the management of the gas system SITA and ENPL have defined responsibilities. Tables 1 and 2 detail the various responsibilities designated to each of the companies.

Table 1: Responsibility for Inspection, Maintenance and Servicing

Operation	Activity	Responsibility	Subject to Approval by
Design	Gas extraction wells Gas extraction De-watering system	ENPL	SITA
Construction	Gas extraction wells Gas extraction Dewatering system	ENPL	SITA
Installation	Gas engines Gas flare Gas extraction wells Gas extraction pipework Dewatering system	ENPL	SITA
Quality assurance	Gas extraction wells Gas extraction Dewatering system	ENPL	SITA
Operation	Gas Flares Gas extraction wells Gas extraction Dewatering system	ENPL	SITA
Inspection	Gas Flares Gas extraction wells Gas extraction Dewatering system	ENPL	SITA
Maintenance	Gas Flares Gas extraction wells Gas extraction Dewatering system	ENPL	SITA
Operations, Inspection and Maintenance	Gas Engines	ENPL	SITA

Table 2: Monitoring responsibilities

Monitoring	Responsibility	Reporting to Natural Resource Wales	Relevant section of the MMP
Perimeter Boreholes	SITA	SITA	2.1 – 2.4
Surface Emissions	SITA	SITA	2.10
Gas extraction Wells	ENPL	SITA	2.5 – 2.8
Flare stack emissions	ENPL	SITA	2.9
Trace Inlet Gas	ENPL	SITA	2.9
Gas Engine Emissions	ENPL	SITA	2.9

3 SOURCE TERMS

3.1 WASTE INPUTS

As of 20/11/2013 the total remaining pre-settlement airspace of the site, up to and including the proposed valley is approximately 2,436,189M3.

Waste inputs to the site began in 1985 with around 2,411,302M3 of air space having been filled of up to November 2013. The current remaining engineered void space was calculated at the close of 2013 as being approximately 131,452 M3.

Phase 1 of Withyhedge Landfill has accepted waste since 1985 until the cessation of landfilling in 2007. This phase was progressively filled through 15 cells with the majority of these capped by 2007.

Waste inputs were overseen by the Local Authority under a resolution until 1997 and inputs during that time can be assumed to be largely Household Commercial and Industrial waste.

Phase 2 of the site was permitted in 2005 to receive non-hazardous wastes at a maximal input rate of 250,000tonnes.

3.2 GAS MODELLING & RISK ASSESSMENT

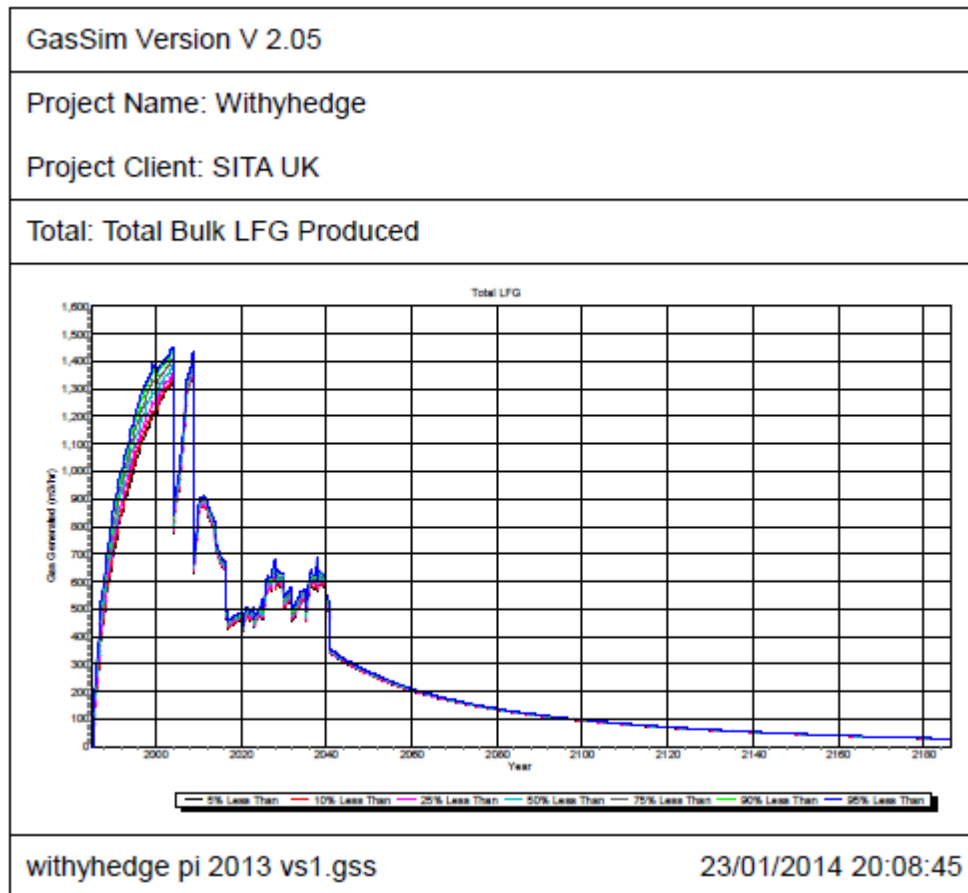
Landfill gas production at Withyhedge has been modelled on Gassim 2.05. This uses established gas production formulae, updated annually with actual waste import data and revised forecast data.

The data is calibrated to show the forecast increase of gas production and subsequent decline following closure and restoration of the site.

The model is used to ensure that emissions to air from sources of landfill gas are fully assessed and present no harm to human health, pollution of the environment or serious detriment to the amenity.

The Gassim Model has recently been updated to take account of the additional landfill void that will be created by the proposed valley. The revised gas curve is provided below.

3.3 GAS EXTRACTION AND SYSTEM CAPACITY



The 50 percentile plot indicates gas production rate of approximately 720M3/hr in 2014. The model suggests that the site is past its peak with peak production modelled at around 1400 M3/hr during 2008. This observed decline in gas production from the site correlates with the significant drop in waste inputs at the site over the last four years.

The gas collection system is designed with sufficient capacity to accommodate the maximum flow predicted from the gas production curve. Pipe sizes will be determined using SPF054 Flow Diagram for Gas Pipes.

4 GAS CONTROL MEASURES

4.1 GAS FIELD OPERATION AND MAINTENANCE

SITA Power utilise internet based tools for analysis of gasfield operation and also for control of maintenance and remediation. ENPL adopt similar protocols and internet based gas management programmes to manage gasfield operation. Specific protocols regarding the process of gas balancing is included in the Appendix B. It should be noted that ENPL utilise gas quality, suction and flow data to optimise landfill gas balancing.

4.1.1 Gas Field Balancing

Gas Field Balancing will be undertaken in accordance with the ENPL Field Balancing protocol in Appendix B. A sample of gas balance report and gas well condition survey is included in Appendix B.

Logs will be kept of the monitoring and any adjustments made. During normal operation the gas quality will be monitored daily at the gas plant and weekly at manifold outlets.

4.1.2 Gas Collection System Maintenance

The general maintenance arrangements for the site are provided in SPOP027 Landfill Gas System Development Procedure and further detailed in SPOP003 Gas Field Balancing and Gas System Inspection Procedure.

In the event of the failure of a gas well an assessment of the well data and its location within the site will be used to determine the need for replacement.

Whilst undertaking routine balancing, ENPL staff are required to investigate and identify faults.

The location and nature of any damage will be reported to the Landfill Site Manager. ENPL will take prompt and appropriate action in arranging repair of the damage. If possible a temporary fix will be made prior to leaving site, pending permanent repair. A record will be kept in a site log of all remedial actions undertaken.

An annual audit of the gas field will be undertaken to highlight any possible defects and necessary remedial works.

The general arrangement of the Withyhedge Gas Collection System is detailed in drawing SN103-4-WITHY-001 GCS.

4.1.3 Prevention of Combustion

The potential for landfill combustion is minimised by careful operation in accordance with Procedure SPOP 020 Prevention or Control of Sub-Surface Landfill Combustion. This also provides the procedure to be followed in the event of combustion being detected.

4.1.4 Winterisation

In order to prepare the site for periods of inclement weather and specifically severe winters, a programme of winterisation will be put into place. This includes a number of measures to be implemented in preparation for the freezing weather.

4.1.5 Gas Treatment

In line with efforts to improve gas systems on landfill sites, the design of gas extraction systems operated by SITA Power is also subject to continual review. The standard configuration for gas utilisation equipment is detailed in SPOP028 Gas Utilisation and Flaring Systems.

The general arrangement of the Withyhedge Gas Utilisation Plan is detailed in drawing NPL4-03-002.

5 GAS TREATMENT PLANT

The primary means of gas control on the Withyhedge landfill site is provided by the boosters & flare system. In the event of failure of the gas engine the flare system is sized to accept the total flow from the landfill site.

In the event of a failure of the site booster, the cause of the defect will be investigated by ENPL and identified. An initial verbal report will be made to SITA and the ENPL Area Manager. In the event a repair of the booster can be made quickly, ENPL will perform utilising engineering capabilities and utilising spare parts kept on site. In the event that the fault requires spares not held on site (e.g. complete electric motor), suitable parts will be sourced from ENPL central store facility.

In the event that the booster is unable to be repaired within ENPL engineering capabilities, an agreement is in place with FBG Services Ltd , to attend site. The arrangement provided the ability to repair the booster, or in the event no repair is possible, replace the complete booster with the suitable equipment held by ENPL within the period of twenty four (24) hours.

In addition ENPL has access to several suitable replacement gas plants from Biogas Technology Ltd (sister company within ENER-G Group).

5.1 GAS FLARE

The flare at Withyhedge landfill site will be used to ensure sufficient gas treatment capacity is available in the event of an engine breakdown.

At Withyhedge there is a single 2000M³/hr high temperature ground flare with automatic flame temperature control. This will burn with a combustion chamber temperature of 1000°C minimum when the methane concentration is above 25%. Minimum residence time is approximately 0.5 seconds.

The turn down ratio is 5:1; giving a minimum flow of approximately 400M³/hr.

In the unlikely event of a total flare failure, the cause of the defect is to be identified and a verbal report made to Area Manager. If a local repair can be carried out within staff engineering capabilities utilising spare parts kept on site, the repair is to be effected immediately. If the repair of the flare cannot be completed within staff engineering capabilities, an agreement is in place between Biogas Technology and ENPL to attend site

24/7. If the flare is beyond repair, a replacement flare is kept in storage at our sister Company Bio Gas Technology Ltd which can be mobilised and installed on site within 24 hrs.

In the event of a planned or un-planned High Voltage outage to the distribution system, the generators cannot operate. In order to continue gas control activities for the duration of the outage, a portable diesel fuelled generator agreement is in place to provide site power. In order to supply the initial start up current for the site booster, the rating of the generator is of 125kVa or greater. In addition ENPL hold a suitable diesel generator at its central store facility

5.2 GAS ENGINES

ENPL have selected the Caterpillar and Perkins containerised generators to provide power generation at Withyhedge landfill. These units have a proven track record, with highest available efficiency, low emissions and capability to operate with a low and variable gas quality. Consequently these units are considered to meet the BAT requirement.

The existing power plant consists of 1 No. 1136kW and 1 No. 400kW Caterpillar and Perkins spark ignition landfill gas engines.

The following related documents is included in Appendix B

- Critical system failure protocol
- CAT 3516 Specification sheet
- 400kW Perkins (4008 series) Specification sheet
- Booster / Flare Information

5.3 MAINTENANCE

The reliability of gas control measures is dependent upon good maintenance procedures for the Gas Utilisation Plant.

Periodic maintenance of Gas Utilisation Equipment maintenance is undertaken as follows:

Frequency of Check	Maintenance Checks
Weekly	Check ignition voltages re-gap spark plugs with reading > 25kV Sample oil & send for condition monitoring.

As necessary	Change oil depending on analysis results Change container air filters, as determined by pressure measurement Change gas filters, as determined by pressure measurement Overhaul charge air cooler, as determined by pressure measurement
1,000 hours	Carry out maintenance as specified in the Caterpillar and Perkins manual ⁽¹⁾
4,000 hours	Grease alternator bearings Grease gas pump bearings Carry out borescopic inspection Check emissions & adjust mixture as necessary
12,000 hours	Turbocharger change.
20,000 hours	Carry out top end overhaul and change crank shaft vibration dampers, includes fitting service exchange cylinder heads & de-coking combustion space
40,000 hours	Carry out bottom and overhaul, includes replacement of pistons, liners and large end shells, replace crankshaft main bearings
80,000 hours	Drive train replacement

⁽¹⁾ Maintenance manual located in the ENPL office, and online.

5.4 INCIDENT RESPONSE

The correct operation of the flare and engines can be checked by reference to the engine control screen. Engine data can be monitored remotely via the internet

Both engines are fitted with an automatic dial out systems which sends an SOS call to a pre-programmed area on-call phone and is diverted to the ENPL on-call technician..

Upon failure of the gas engine, the flare system automatically operates to ensure that gas is incinerated and suction maintained to the landfill site. In the event the engine cannot be started remotely, the ENPL on-call technician will respond to the automatic SOS call, investigate the fault and initiate the appropriate remedial action.

In addition to automated monitoring of the engines, ENPL have in place a twice daily manual dial in system.. During the dial in certain variables are checked and referenced against Engine Parameter tables for each engine.

In the event a site attendance is required for fault or preventative maintenance, this can usually be achieved within 2 hours of notification.

Partial or total system failures which exceed 24 hours are regarded as an incident which should be notified to NRW.

6 DEVELOPMENT OF GAS CONTROL SYSTEMS

The development of gas control infrastructure continues throughout the life of a landfill site in accordance with Procedure SPOP027, Landfill Gas Development Procedure. This includes

- Initial design and planning
- Co-ordination of operations, engineering and gas management.
- Standard design of gas systems
- Accommodation of engineering and restoration works

6.1 CONSTRUCTION QUALITY ASSURANCE (CQA)

All permanent elements of the gas control system will be constructed to an agreed design specification and assessed in accordance with recognised standards and methodologies. Construction Quality Assurance measures will be applied in accordance with Clause 7.1.2 of LFTGN03 Guidance on the Management of Landfill Gas and will be “pragmatic and commensurate with the potential consequences of failure of the plant and equipment concerned”.

Sacrificial systems will be designed to be robust and capable of withstanding site activities and settlement but will be expected to fail after a reasonable period of operation.

6.1.1 Installation of Gas Wells

The design of new gas wells is closely managed by SITA Power to avoid damaging the basal liner. These operations are covered by procedures SPOP004; Drilling into Landfill Waste and SPOP005; Gas Well Setting Out Procedure.

6.1.2 Installation of Gas Systems

Minor works on SITA sites may be undertaken by properly trained ENPL staff. Such works might include, extending gas wells, relocating gas manifolds, replacing damaged flow lines, installing temporary systems, and disconnection/reconnection of lines.

Significant works will generally be undertaken by contractors. Such works are governed by a series of procedures drafted to maintain standards in Environmental Compliance, Health & Safety and Quality Assurance. These procedures define standards and act as instructions to the contractor:

SPOP 023	Procedure for Engineering & Construction Contracts
SPOP 024	Instructions to Contractors Construction & Environmental
SPOP 025	Instructions to Contractors Construction Quality Assurance
SPOP 026	Engineering & Construction Contracts Health & Safety

6.1.3 Standard Designs

All engineering work is undertaken in accordance with good engineering practice, utilising standard materials and components and to this end SITA UK Ltd have adopted standard designs for critical gas control components. ENPL operate under a similar principle and their designs provide the same standard of quality and reliability. Components used in the development and remediation of the gas control system will be in accordance with the following standard designs

ENPL-40-003-3	Standard Gas Well and Well Head Layout
---	Design Manifold Box
SPSD005	SITA Power Boot Detail Drawing
SPSD005	SITA Power Boot Detail Table
SPSD005A	SITA Power Leachate Tower Boot Detail
SPSD007	Spike wells construction
SPSD008	Horizontal Gas Well Design
SPF054	Flow Diagram for Gas Pipes

7 ENVIRONMENTAL MONITORING

The Monitoring Management Plan details the methods, frequency and standards required for environmental monitoring at the site. In general environmental monitoring serves two purposes:

Permitted Emissions	Gas Engines and Flare Systems are monitored to ensure that exhaust and flare gas components are controlled within permitted levels.
Fugitive Emissions	Gas migration boreholes, Surface Emissions Monitoring and odour checks are undertaken to ensure that fugitive emissions do not give rise to hazard or nuisance.

7.1 PERMITTED EMISSIONS

In the event of emissions test results for the Gas Utilisation Plant exceeding limits provided in the permit, ENPL shall provide details to the Site Manager and the SITA Power Operations Manager.

These details will include the nature and potential effect of the exceedances and the actions proposed to bring the emissions within permitted levels.

Notification of emissions exceedances and proposed actions will be supplied to NRW by the Compliance Manager usually within 48hrs of receipt.

7.2 FUGITIVE EMISSIONS

In the event of gas migration exceeding trigger levels, ENPL will assess and investigate the likely cause of the exceedance and initiate action to eliminate or control the migration. Such action will include adjustment of flow at specific gas wells, remediation of equipment or proposal to augment or replace gas infrastructure.

Air-borne emissions detected by odour inspections or compliance monitoring (e.g. Surface Emissions Monitoring) will be addressed in the same manner.

ENPL shall provide details to the SITA Power Operations Manager of the nature and potential effect of any fugitive emissions and the action proposed to bring the emissions within permitted levels.

Notification of fugitive emissions and proposed actions will be supplied to NRW via the SITA Compliance Manager within 24 hours of receipt (see Table 2).

7.3 PROCEDURE FOR NON-ROUTINE EVENTS

Abnormal conditions may arise in the operation of the gas management system:

- Abnormal monitoring data
- Operational problems
- Failure of the gas control system
- Reported event

In the event of any release of gas or odour having a potential impact on the local air quality or human health, this will be investigated to identify the root cause. Prompt action will be taken as necessary to minimise any impact.

Gas Control Contingency Measures are included within the relevant section of the Monitoring Management Plan.

7.4 ODOUR MANAGEMENT PLAN

Odours can arise at landfill sites from fresh or uncovered waste, gas escapes or leachate vapours. The Odour Management Plan for Withyhedge Landfill Site details the odour inspection regime along with action plans designed to rectify any sources of odour identified. Community complaints and observations by NRW are also resolved by the Odour Management Plan which ensures a comprehensive response to identifying and solving the root cause of odour emissions in a timely manner.

7.4.1 Hydrogen Sulphide

Analysis of landfill gas at Withyhedge has identified elevated Hydrogen Sulphide at levels of 270 ppm. At such high levels Hydrogen Sulphide presents two issues:

Occupational Health – H₂S is above the levels at which it is a risk to those working around infrastructure which contains landfill gas.

Community/Amenity – Minor leaks of H₂S bearing landfill gas can create significant odours and loss of amenity over a large area.

SITA UK have therefore implemented the following operational procedures.

SPSWP015 Working with Hydrogen Sulphide.

SPCOS004 Hydrogen Sulphide CoSHH Data sheet

SPHSP006 Personal Gas Alarms Procedure

In addition to these procedures and as a further precautionary measure, gas/leachate wells on site which have displayed high levels of H₂S have been clearly marked up.

7.4.2 Community/Amenity

SITA UK will, where practicable, reinforce normal landfill gas control measures by:

- Installation of horizontal gas collection lines in active areas.
- Increased attention to dressing and maintenance of temporary capped areas.
- Use of recoverable gas collection probes in accordance with SPSWP016; Installation of LFG Collection Probes
- Close coordination between the Landfill Site Manager and the Gas Control Supervisor to ensure prompt response and investigation of odour reports.

RESOURCE MANAGEMENT (UK) LIMITED

Witheyhedge Landfill Site

Leachate Recirculation System

ADDENDUM TO THE GAS MANAGEMENT PLAN

Document No. AGMP/WHAug16/02

August 2016

Prepared for
Resource Management (UK) Ltd

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Document Review

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Checked by	Velma Finney	26/09/2016
Authorised by	Tim Keay	26/09/2016

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Existing Gas Management Plan (GMP)

The existing gas management plan can be seen as Withyhedge Landfill Site Gas Management Plan 2014 V2 and includes a general description of the Gas management philosophy at the Withyhedge site. The plan was written by SITA and includes a management structure for the site that quite clearly identifies EnerG working under SITA Power. The management configuration is that the Permit holder is directly and ultimately responsible for gas control at the site. In order to ensure that leachate recirculation does not have an adverse impact on landfill gas generation, collection and management it is imperative that lines of communication are continued and where necessary developed further.

The Gas management plan, "Field balancing document" shows that the existing protocols seem particularly robust and indeed, the contents of Appendix B to that document are what would be considered to be good industry practice for normal landfill gas management. To ensure integrated management it is essential that lines of communication are continued between the Permit holder and EnerG, especially considering that recirculation of leachate may introduce new management issues, as covered in this document given that landfill gas production rates are expected to increase in the area of leachate re-circulation.

A review of the existing gas collection system by considering the plans and by a site visit has shown that the existing infrastructure has been decommissioned in the recirculation area. It is also apparent that there is no gas currently measurable in those parts of site where recirculation is planned, this explains why the system has been decommissioned. It is expected that the cell that is dry entombed will not produce much gas if any at all which is the current situation, recirculation of leachate is intended to restart gas production. Wells that are currently decommissioned have already been assessed along with manifolds and will be physically investigated for integrity at surface and bentonite seals replaced at the same time that the leachate recirculation system infrastructure is installed and prior to leachate recirculation commencing. The existing wells will be reconnected and additional wells installed, these can be seen in drawing LFS-00104-WH/02 and include the following wells:-

- 1) WIPK0019
- 2) WIVJ0092
- 3) WIVJ0093
- 4) WIVJ0094
- 5) WIVJ0010
- 6) WIVJ0011
- 7) WIVJ0012

Re-connected gas wells and manifolds in the recirculation area will be assessed and their condition with any remedial works recorded and presented as a Construction Quality Assurance document. This will include photographic evidence of repairs made. This adds to 4.1.2 of page 14 of the existing Gas Management Plan.

The introduction of leachate recirculation means that a review of procedures has been essential and the following protocols will need to be introduced in addition to those already used:

The table contents seen in 5.13 identify potential issues such as well blockages and what will be done. Section 7. States that “Gas Field Reviews Periodic reviews are carried out to assess individual GCS performance”.

In 7.1 there is a commitment “To fully assess the performance of wells and collection efficiency, the following data is required:

- Flow checks – to determine any restrictions.
- Well dips – to determine blocked, collapsing or submerged wells from site leachate.
- Gas Field Trending Data – to long term analyse data to assess performance.
- Camera surveys – visual verification within well liners.
 - Image maps or similar – to identify areas on the gas field where aerobic activity or other changes are taking place.”

In 7.2 it states: “Further works may be required following review of the above data. These could include:

- “Replacement wells.
- Replacement collectors.”

In the event that gas wells are not responsive Section 7 will be invoked immediately on any gas wells collecting gas in the recirculation area.

The recirculation of leachate should not lead to accumulations of liquid in the gas collection system, however as a precautionary measure additional methods for detecting blockages will need to be used.

Actions: Differential pressure readings will be considered by the Permit holder at different points of the collector main, for instance at the well head and the manifold. This will identify disconnections in the pipe and blockages in a particular section. In the event of a blockage being discovered via this manner it will need to be reported immediately to the Permit holder so that they can take appropriate action with respect to leachate recirculation.

The Existing Gas Management Plan “Withyhedge Landfill Site Gas Management Plan January 2014 V2 on page 14 and 15 addresses Gas Control Measures in 4 through to 4.1.5

The EnerG report should be read in conjunction with the Gas Management Plan with 10.6.2 of and 10.6.4 of the Gas Processing Report being relevant. The installation of the leachate recirculation system is expected to generate landfill gas; in order to assess any changes, the monitoring and balancing of landfill gas in the recirculation cell gas wells will be maintained at a weekly interval and reported this does not alter 10.6.2 and 10.6.4. The Gas field balancing protocols in the Gas Processing Report do not alter apart from an increase

in monitoring frequency in the Recirculation area.

It is anticipated that landfill gas rates will increase over approximately 12 months of introducing leachate recirculation, the modelled uplifts can be seen in the Grasim Lite models below and the existing gas collection system has sufficient capacity to collect additional gas once it has been reconnected and reinstated prior to leachate recirculation commencing. The intent is to collect the extra gas and divert to the GUP. The gas collection system will have sufficient capacity to collect additional gas generated before leachate recirculation commences with decommissioned wells having been recommissioned and additional wells being installed in areas where there are gaps in gas infrastructure in the area of recirculation. Early detection of uplift is essential so that additional gases can be utilized immediately. This will require increased weekly monitoring of the gas wells and this will be carried out by the permit holder. Early signs of uplift will include the additional delivery of gas to the GUP with a decrease in vacuum. In 5.22 on page 12 of Appendix 2 of Gas Management Plan it can be seen that adjustments are made in load adjustment circumstances, in the case where there is more gas, the same adjustments and notifications will be made to the Permit holder as this is an indicator of higher gas production rates.

5.22 Load adjustment may be required post balance to control the rate of gas extraction, this will be done by the Permit Holder:

- As a guideline, if site vacuum increases as a direct result of the balance, load reduction is evaluated to prevent over extraction.
- If site vacuum decreases, it is recommended that the field is allowed to stabilise for at least 24hrs before evaluating load adjustment.
- Early signs of uplift will include the additional delivery of gas to the GUP with a decrease in vacuum., in the case where there is more gas, the same adjustments and notifications will be made to the Permit holder as per 5.22 of Appendix 2 (as this is an indicator of higher gas production rates).

Actions: In the event of additional gas being generated during recirculation of leachate the need for the installation of additional wells will be reviewed. In the event that there are gaps in the gas collection system new wells will be installed or the existing system will be reinstated before leachate recirculation commences. This is in accordance with 4.1.2 of the found on page 14 of the Gas Management plan and is specific to the re-circulation of leachate.

GasSim Assessment

The GasSim model for the site demonstrates that gas production rates should now be in the order of 720m³per hour of landfill gas which is a consequence of waste being “Dry”. By recirculating leachate waste will become wetter and increased gas production rates are anticipated as a consequence of design to increase. They are not expected to increase beyond the maximum gas production rates set in the current GasSim. The emissions section of the GasSim model and plant requirements are unlikely to change as numbers and type of engines and flares will remain as per maximum gas generation rates in the existing GasSim. If this were to change then this will trigger a new GasSim assessment prior to the installation of new combustion equipment.

The GasSim model for the whole site suggests that the maximum volumes of gas being produced for the whole site would be 1400m³/hr. Page 13 of the Gas Management Plan states that the 50 percentile plot indicates gas production rate of approximately 720m³/hour in 2014.

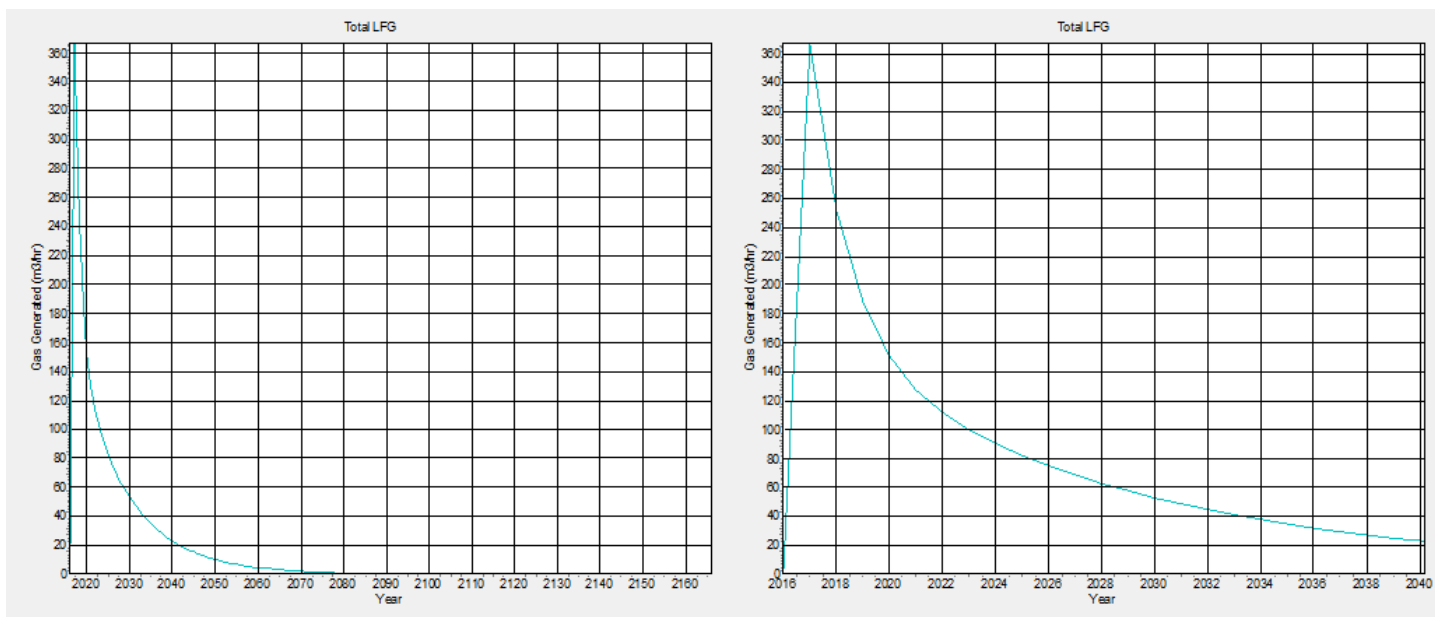
Gas Collection Infrastructure Review

A physical inspection of gas wells at site and review of the gas collection infrastructure plan *LFS-00104-WH/02* has been carried out for the area where leachate recirculation is proposed at Withyhedge landfill. The cell has been considered for:

- Whether gas wells and carriers have been de-commissioned
- Gas well seals and integrity of the collector pipework
- Density of gas wells
- Carrier pipe sizes; and
- Maximum volumes of gas collectable via each pipe diameter

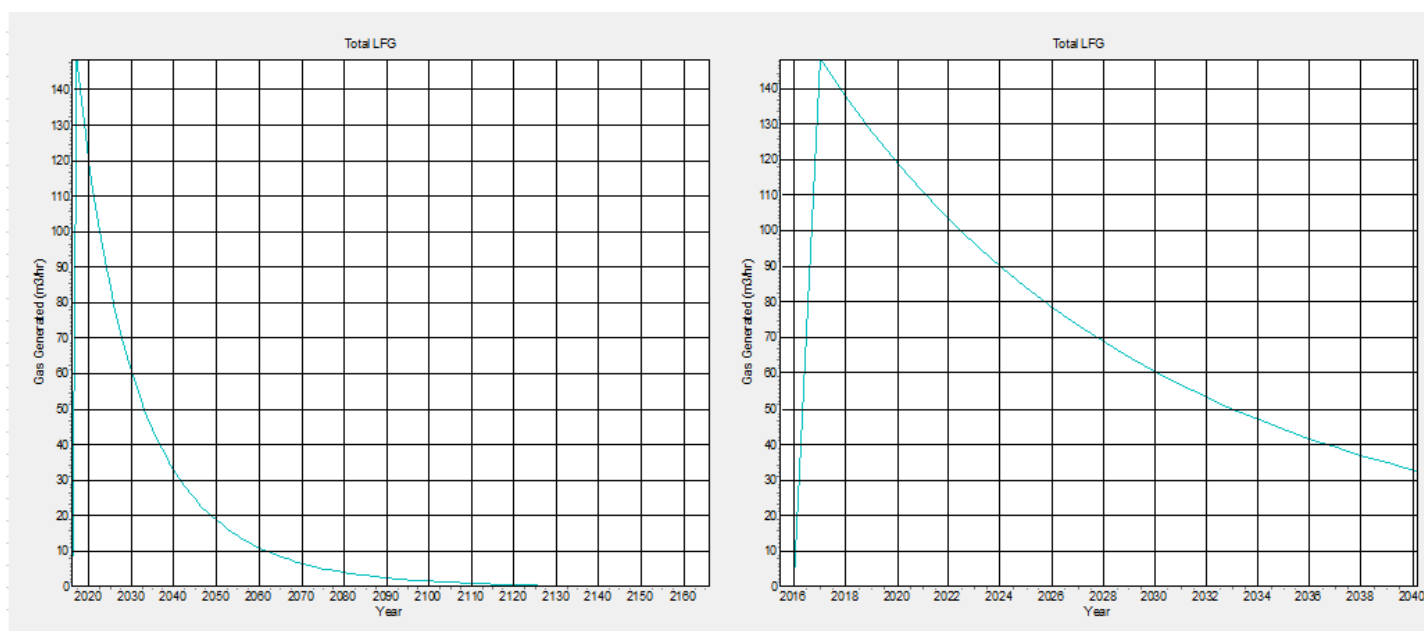
A review of the gas management system plan shows that the existing gas collector is capable of collecting 567m^3 gas per hour (velocity of 10m sec^{-1}) being collectable via the northern 160mm 17.6 SDR collector and 720m^3 per hour via the Southern 180mm 17.6 SDR pipe. The Northern section of the cell has 24 gas wells, the southern section has 10 wells. The initial phase of leachate recirculation is expected to affect the area with 10 wells in it. We know that waste in the cell is dry from the resistivity survey already carried out but the degree of degradation is impossible to accurately. The existing gas collector is capable of collecting 85% of 1400m^3 gas per hour which equates to 1190m^3 , which is the volume of gas predicted to be produced at peak production in full GasSim for the site. This assessment of capacity of the larger carriers indicates the system has sufficient capacity to collect gas across the whole site

To assess that the gas collection system is able to collect all of the gas that **might** be produced in the recirculation cell, a simple GasSim Lite model has been developed. The model assumes the waste has already decayed to a degree before waste dried out. It has also been assumed that 50% of the waste in the cell still has gas production potential. The impact of recirculation assumes in the first scenario that the waste will become “wet” in the model 216,000 cubic metres (the model uses 259,000 tonnes based on a compaction ratio 1.2 t/m^3) of waste are in the cell that is to be recirculated into. The Gassim Lite production curve (50 percentile) can be seen under these conditions. The maximum gas production rate is predicted in 2017 and is $370\text{m}^3/\text{hour}$. This is considered to be conservative estimate of potential uplift. At 85% collection rate we would expect to see $314\text{m}^3/\text{hour}$ landfill gas collected.



Gassim Lite – “Wet” Conditions – Recirculation Cell

To give a range of modelled outputs a model with “Average” moisture conditions has also been considered and the Gassim Lite production curve (50 percentile) can be seen under these conditions. The maximum volume of gas predicted in that model is 150m³/hour and this is in 2017.



Gassim Lite – “Average” Conditions – Recirculation Cell

In either scenario there will be sufficient gas wells installed that are functioning and these can be seen in drawing LFS-00104-WH/02

The Gassim Lite models add to the existing Gassim that can be seen on page 13 of the Withyhedge Landfill Site Gas Management Plan January 2014 V2. It applies to the recirculation areas of waste only. This is an addendum to the 2014 document and is present to estimate what levels of gas increase might be seen.

As installers of the LRS we are aware that there is a buried sacrificial horizontal collector that needs to be accommodated in the cell when recirculation commences. We have been informed by the Permit holder that this horizontal collector is immediately below the capping layer and is currently dis-connected from the gas collection system and decommissioned permanently.

The impacts of the horizontal collector by potential leachate introduction will be prevented by only introducing leachate at a depth greater than 1m below the level of this horizontal system.

Action: If the horizontal collector is intercepted it will be further decommissioned by chasing the pipe back one metre and sealing each end with a bentonite plug. (Inc, in CQA procedure)

Action: A photographic record will be taken of the decommissioned collector, the location given a unique reference and its location noted on the final CQA report.

One of the primary reasons for leachate recirculation at Withyhedge is to generate gas in a more manageable way and any additional gas produced will be collected via field balancing techniques where Methane, Carbon Dioxide, Oxygen, Balance gas and differential Pressure are managed to collect all gas safely. In any case the collection of gas will be managed in accordance with 4.1.1 of the GMP – “Gas Field Balancing”. In the event that additional gas is required the following action will be required to capture gas and send to the GUP for energy production:

Actions: In the event of additional gas being generated the need for installation of additional wells will need to be considered. This will be based on the efficacy of the current design, gap analysis to include wells that are turned off or in need of repair, balancing, emissions survey and emissions observations, gas well pressures and carrier sizes. An assessment of this detail will need to be made by EnerG on a monthly basis and reported back to the Permit holder.

Actions: In the event that additional gas wells are required a review of gas collector main will be required to demonstrate the existing main has sufficient capacity to accept the maximum quantity of gas anticipated. There is potential

to create a ring main from the existing gas collectors and this may be the most cost effective means of collecting additional gas. If needed.

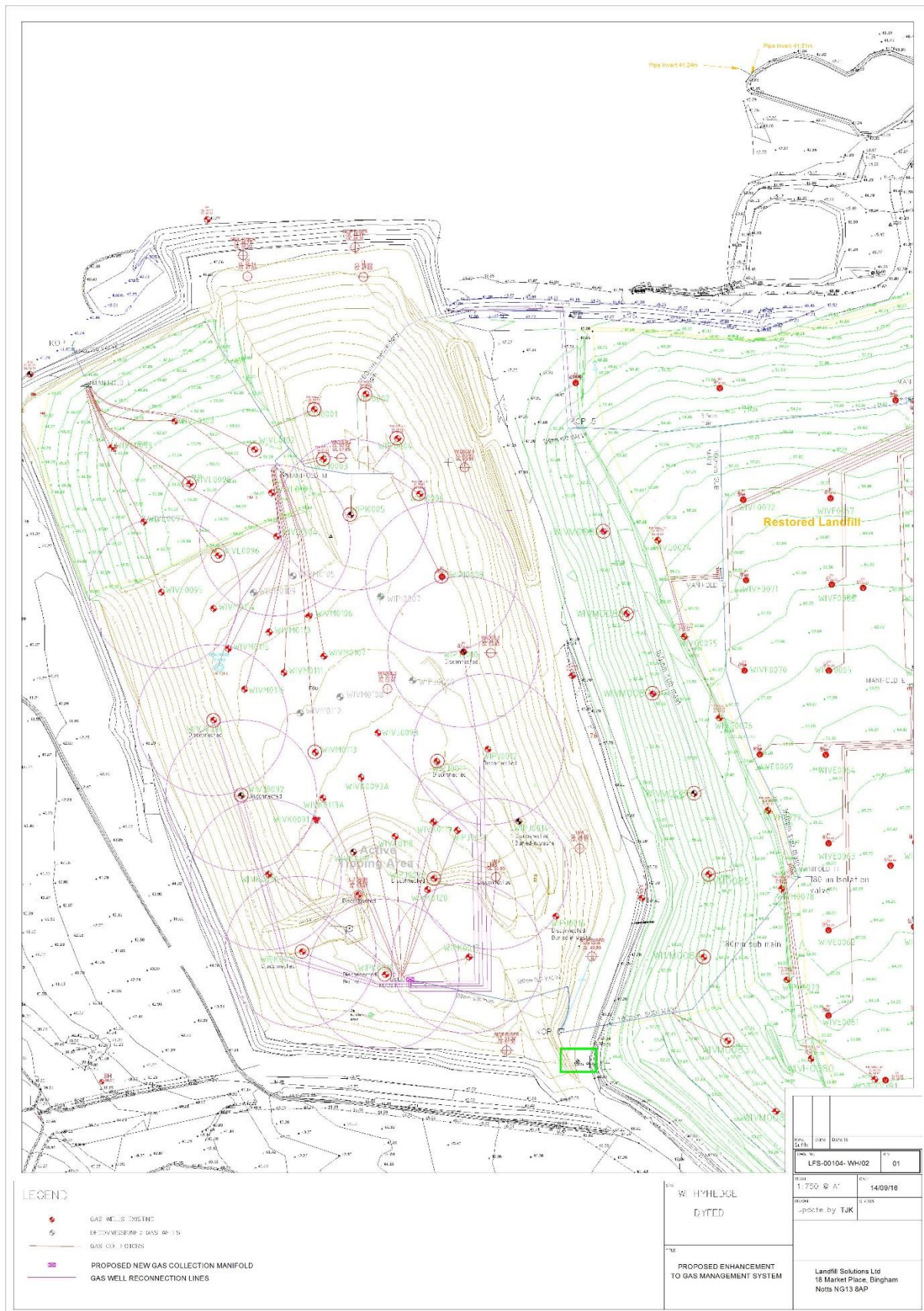
Additional gas production will mean that additional condensate will be produced. The existing gas control system is designed to remove condensate within the range of the volumes of gas suspected to be produced and as a pumped system should not present issues with condensate build up. Any condensate blockages will be intercepted via normal gas field balancing in accordance with the existing Gas Management plan and balancing protocols as per Appendix B to the GMP.

Actions: Extra vigilance will need to be taken by the Permit holder when the gas control system is being balanced especially where there is obvious uplift in gas production. Not only will field balancing be carried out but observations will be made that relate to accelerated settlement that may occur as a result of loss of mass as a result of landfill gas production. In light of this, gas balancing in the recirculation area will be reviewed weekly by the permit holder with an increase in frequency considered based on the rate of changes and in particular where positive pressure is seen in wells reducing again to weekly once gas generation has stabilized.

This adds to the existing section of the Gas monitoring and balancing protocol contained in 10.6.8 found on page 9 of the Energy Field balancing documentation and applies to the Leachate Recirculation area.

We are also aware that there is a buried sacrificial horizontal collector that needs to be accommodated in the cell when recirculation commences. This will be decommissioned and a CQA record made of the works carried out. This will include photographic evidence and this will be presented to NRW.

Drawing LFS-00104-WH/02



Exea Associates Limited

Environmental Compliance and making money for our customers

WITHYHEDGE LANDFILL SITE

Landfill Gas Risk Assessment Report 1

Permit EPR/GP3630HT/V005

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DATE January 2018	SIGNATURE 	SIGNATURE 	SIGNATURE 

LANDFILL GAS GENERATION AND RISK ASSESSMENT

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1.0 INTRODUCTION

This Model was originally created for a Landfill Gas Risk Assessment April 2013 for SITA and has been modified in 2017/18 to demonstrate emissions post- recirculation of leachate at the Withyhedge site via the system designed and installed by Landfill Solutions Ltd. Without this model being accepted recirculation cannot commence. This model considers maximum emissions from 3x1mw engines in 2018 and waste inputs have been artificially enhanced to generate additional gas. Adjustment of moisture content in the model does not increase gas generation to the volumes of gas where three engines could be supported, waste inputs have therefore been significantly increased in the model in Phase 2, Cell 4 (2017) These are the cells where extra gas is hoped to be generated and are already fully capped and have leachate recirculation and additional gas wells already installed in accordance with a full CQA. In reality, the waste within that cell is “average” and the point of recirculation is to increase moisture content to “wet” in order to reactivate gas production. Adjacent cells that have recently completed are also full of “dry” waste due to a practice of continuous temporary capping and full capping. Early capping is used to minimise surface emissions and odour complaints but can result in waste being dry and lowering gas generation rates. This is supported by the Gassim model where gas production volumes are influenced by waste composition via Cellulose/Hemi Cellulose content and moisture content. Lower moisture content will reduce in a lowering of gas generation and elongation of the gas generation curve, improving moisture content will increase gas generation and shorten the gas generation curve. In all cases the volume of gas generated is exactly the same over the gas generation lifecycle and gas cannot be “made”.

This is an important factor in as much as conventional modelling already carried out at this site has demonstrated that 2.4MW production is acceptable and the science behind the Gassim algorithms would suggest that the existing Gas Utilisation Plant (GUP) capacity cannot be exceeded by recirculation (See comments regarding evidence)

In theory, gas production from recirculation in this manner will not be capable of generating sufficient gas to introduce an additional 1MW engine. Gas production will be enhanced but it is a common “rule of thumb” that it takes one million tonnes of waste to produce the 600m³/hour of landfill gas required to generate 1MW of electricity. A model that was previously assembled for SITA has been used as the basis of this modelling exercise. The understanding is that this model was not formally accepted by Natural Resources Wales (NRW) but it is a sensible one to use as inputs are appropriate. Exea Associates Limited have modified the inputs to an earlier model to get volumes of gas sufficient to run an extra 1MW engine. Not to make too fine a point we have doubts about the levels of uplift to the engines that have been suggested may be possible, resulting from recirculation of leachate.

This report is written using the format suggested in “Environmental Permitting (England and Wales) Regulations - Information in support of an application for a landfill permit – Version 3 – 2010”. It must be noted that this Gassim is intended only to demonstrate the emissions from an additional 1.MW, increasing engine emissions from 2.4 MW to 3 MW already allowed via the permit. This is in accordance pre-application meetings with Natural Resources Wales in August 2017.

Site cells – taken from the Gassim model for Withyhedge



- A point in August 2017 by NRW related to fugitive emissions via "breather tubes". It is considered that they will be reintroduced to the engines or filtered to avoid additional emission points that could not be sensibly modelled

1.1 Gassim 2.5 – A Gas Risk assessment has been carried out for the Withyhedge landfill site to consider the impact of emissions from an addition engine point source. The Gas Risk assessment is in preparation for Leachate Recirculation at the Withyhedge landfill site that are likely to increase landfill gas generation at the site. The additional gas is required to be collected by the Environmental Permit for the site. The wastes where leachate is to be recirculated are capped and dry and have absorptive field capacity. The addition of leachate to these dry, capped wastes will produce gas to an unknown degree and the Gassim 2.5 model is not designed to accommodate recirculation. The inputs to this Gassim model do not reflect the volumes of waste that have been deposited in the landfill site and have been adjusted to generate sufficient gas to operate 3x1MW engines. The aim of the model is purely to assess the impact of additional gases that **could theoretically** be generated, and there is no guarantee that the volumes identified in the gas generation curve will be seen at the site, what we can see is whether additional emission points will result in unacceptable emissions to the environment. This exercise is necessary and required by Natural Resources Wales before recirculation is allowed. The impact of capping very quickly, and in this case compacting waste over a prolonged period and then capping with low permeability plastic and then placing up to 2 metres of soils/clays that drain to a low point, mean that the waste is nothing like that described in the model.

In practice, the recirculation of leachate will replenish moisture to the waste as per the existing model that was previously submitted and agreed with the Regulator (not to be confused with the template modified for this exercise). This re-modelling should therefore be viewed as an exercise to allow recirculation only and the Regulatory reviewer needs to be aware of this or a position of impasse will be arrived at if not accounted for. In accordance with the Gassim 2.5 manual:

What GasSim2.5 Predicts

According to the Gassim handbook the GasSim2.5 output can be split into eight groups:

- Carbon degradation and LFG generation (cell by cell or total site values);
- Engine and flare emissions (totals), and surface emissions (cell by cell or total site values);
- Tier 1 Atmospheric Screening;
- Tier 2 Atmospheric Dispersion (including odour);
- Lateral migration (including vegetation stress);
- Global atmospheric impact (GWP and ODP); and
- PI reporting.

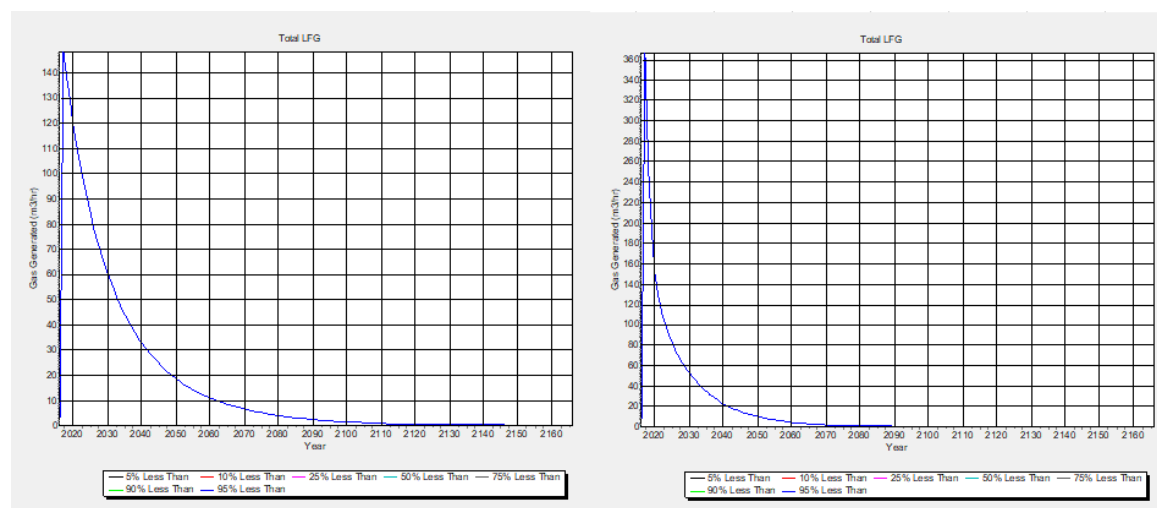
The LFG generation outputs are intended to help you understand the behaviour of the waste degradation and thus the gas production within the landfill. These results should be studied first to ensure that the simulation is responding correctly. Only then should you use the pathway and receptor modules of the model. The emissions module outputs the gas concentrations from flares, engines, the cap, and lateral migration. The atmospheric dispersion model then uses these results. In the case of this model it should be reiterated that the emphasis is to assess the theoretical impact on Tier 1 Screening, Tier 2 Atmospheric Dispersion and Global Atmospheric Impact. The Gassim 2.5 model considers these emissions as the site as a whole and in particular to assess the potential impact of an additional 1MW engine.

In the case of this model the important receptors are the SAC and the SSSI locations as identified in Table LFGRA 1 below. The rationale behind the modelling is not typical.

2. The model

2.1 Inputs - The site has accepted waste since, 1985 and was formerly operated by SITA. The model used here is one that was previously assembled for SITA UK and has been adjusted to generate sufficient gas to require an additional engine. The Withyhedge site is now operated by RML Ltd. As discussed above, the scenario suggested is one that is purely hypothetical and use of Gassim 2.5 in its conventional mode would not generate the volumes required to require an additional engine. The waste inputs to cell 4.2 have been modified and increased to give a maximum generation rate in 2018, it must be reiterated that the inputs are not real, do not reflect reality and are there purely to generate a volume of gas sufficient to require and utilise additional combustion equipment and to introduce a further emission point for emissions assessment, with total engines being 3x1MW units. The basis of this review of emissions is based on comments made by Landfill Solutions Ltd during meetings with NRW (with no scientific basis or evidence provided). Exea Associates Ltd agree that there will be additional gas generated, but our view is that the existing Permitted GUP will be sufficient to manage that extra gas.

Our thoughts on this are partly justified by using simple modelling. Using Gassim Lite the Landfill gas production rate for a cell with 350,000m³ (2010-2013 waste) where deposit occurs over 1 year would be approximately 200m³/hour if the waste is "Average" moisture content. By increasing the moisture content to "Wet" gas generation increases to approximately 600m³/hr. The waste within the Withyhedge cell has been present for some time and is black, has already produced a significant volume of gas. There is a depleted source of cellulose and hemi-cellulose, so we would expect generation rates to be lower than with fresh waste, which means less than an uplift of 400m³/hour from the recirculation cell. An uplift of 300m³/hour would generate an additional 500KW/hour output from engines. Industry "rule of thumb" on gas generation rates suggest that 1 million tonnes of waste will generate 600m³ of landfill gas per hour, this equates to 1MW of electrical output. There is a difference between the industry rule of thumb and the Gassim Lite predictions and this will be down to the volume of waste being wetted over a short period of time. The model assumes that all of the waste will reach optimum moisture content at the same time and this is unlikely and we would expect a more elongated gas generation rate.



The Gassim Lite outputs discussed earlier can be seen above with waste moisture content having been changed from “Average” to “Wet”. This has been done to justify comments made about predicted and suggested uplifts in gas generation.

The full Gassim 2.5 model has considered the trace component data for the site as seen in the table below, it is also included in the Appendices. The data falls well within the ranges of the default concentrations as seen in the Gassim 2.5 model.

Trace Component	Concentration	Trace Component	Concentration
1, 1 - dichloroethane	<33ug/m ³	Chloroethane (vinyl chloride)	<33ug/m ³
1, 2 - dichloroethane	229ug/m ³	Dimethyl disulphate	786ug/m ³
1, 2 - dichloroethane	<33ug/m ³	Dimethyl sulphide	917ug/m ³
1, 1 - dichloroethane	190/ugm ³	Ethanal (acetaldehyde)	512ug/m ³
1, 3 - butadiene	<33ug/m ³	Ethanethiol	589ug/m ³
1 - butanethiol	<33ug/m ³	Ethyl butyrate	<82ug/m ³
1 - pentene	<33ug/m ³	Furan (1,4-epoxy-1,3 butadiene)	<33ug/m ³
1 - propanethiol	<33ug/m ³	Hydrogen Sulphide*	51,607ug/m ³
2 - butoxyl ethanol	<33ug/m ³	Methanal (formaldehyde)	128 ^(a) ug/m ³
Arsenic (as As)	<85ug/m ³	Methanethiol	<98ug/m ³
Benzene	3,602 ^(c) ug/m ³	Styrene	851ug/m ³
Butyric acid	<33ug/m ³	Tetrachloromethane	<33ug/m ³
Carbon disulphide	3,929 ^(a) ug/m ³	Toluene	13,424 ^(c) ug/m ³
Chloroethane	524ug/m ³	Trichloroethane	115ug/m ³

Trace Component taken from Site Analytical data (Appendix 1)	Concentration	Gassim Default values
1, 1 – dichloroethane	<33ug/m ³	2.5 -3,900ug/ m ³
1, 2 – dichloroethane	229ug/m ³	
1, 2 – dichloroethane	<33ug/m ³	
1, 1 – dichloroethane	190ug/m ³	
1, 3 – butadiene	<33ug/m ³	1.0e-30-1.79mg/ m ³
1 – butanethiol	<33ug/m ³	1E-30-1.0mg/ m ³
1 – pentene	<33ug/m ³	33-12,000ug/ m ³
1 – propanethiol	<33ug/m ³	1e-33 -5.80mg/ m ³
2 - butoxyl ethanol	<33ug/m ³	1e-33-3.66mg/ m ³
Arsenic (as As)	<85ug/m ³	1e-4 -0.1116 -0.43mg/ m ³
Benzene	3,602 ^(c) ug/m ³	933-7300ug/m ³
Butyric acid	<33ug/m ³	1e-30- 1.75emg/ m ³
Carbon disulphide	3,929 ^(a) ug/m ³	0.52-170mg/ m ³
Chloroethane	524ug/m ³	1.0e-30-5.30mg/ m ³
Chloroethene (vinyl chloride)	<33ug/m ³	2.5-730000ug/ m ³
Dimethyl disulphide	786ug/m ³	2.5-12000ug/ m ³
Dimethyl sulphate	917/ug/m ³	
Ethanal (acetaldehyde)	512ug/m ³	50-2456ug/ m ³
Ethanethiol	589ug/m ³	1e-30-13800ug/m ³
Ethyl butyrate	<82ug/m ³	4.2-42000ug/ m ³
Furan (1,4-epoxy-1,3 butadiene)	<33ug/m ³	2.5-6200ug/ m ³
Hydrogen Sulphide*	51,607ug/m ³	2400-87000ug/ m ³
Methanal (formaldehyde)	128 ^(a) ug/m ³	26-255000ug/ m ³
Methanethiol	<98ug/m ³	1e-30-8400ug/ m ³
Styrene	851ug/m ³	
Tetrachloromethane	<33ug/m ³	
Toluene	13,424 ^(c) ug/m ³	10-1250000ug/ m ³
Trichloroethane	115ug/m ³	4-1000-10000ug/ m ³

In all cases the model defaults are in excess of trace component concentrations found in the Withyhedge gases that can be seen in the above table. The comparisons can be seen in the table above and the model has been run conservatively to assess the impact of gaseous emissions from 3x1MW engines. It is anticipated that the impacts will be acceptable, however should the simulation show unacceptable environmental impact, the inputs will be modified to reflect the trace component concentrations found on site.

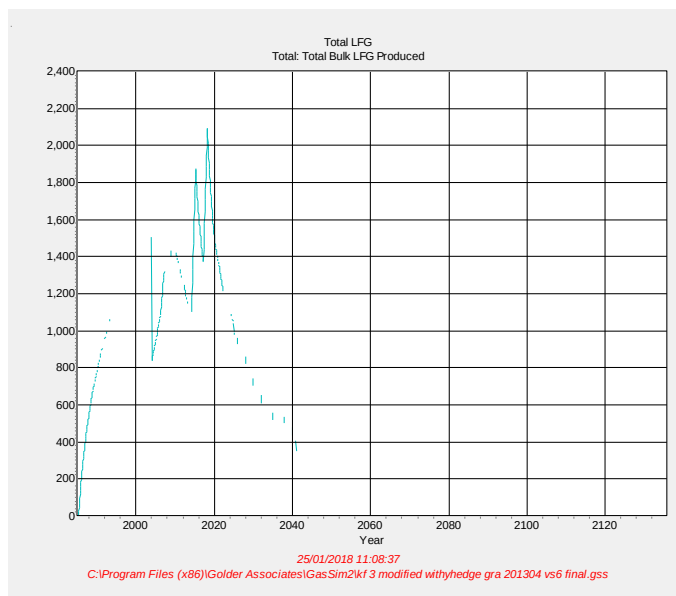
To reiterate the point made throughout this document, the model is designed to demonstrate what might happen if 3 x1MW engines are needed following on from recirculation of leachate. This is a theoretical scenario and a degree of pragmatism will need to be applied when considering the model parameters. This point cannot be over-stressed.

2.2 Outputs –

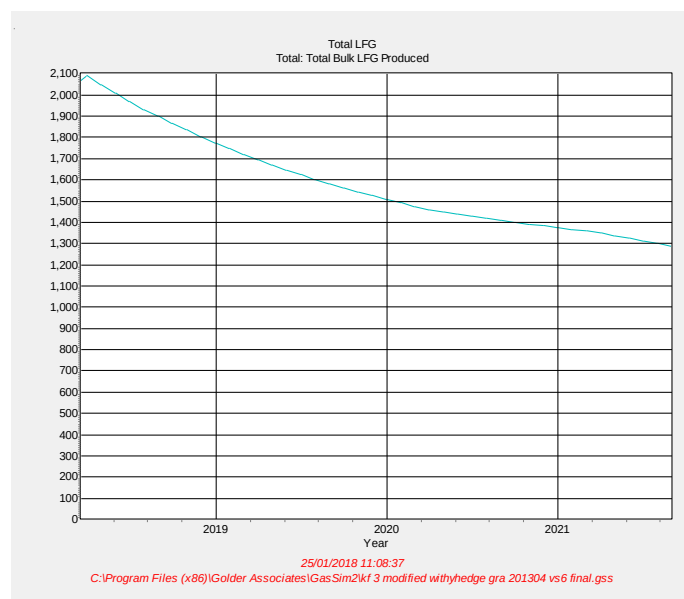
Please Note: The following message opens when running the model and is a consequence of previous modelling. It relates to an area of overtight which does not influence the aspects of assessment we are concerned with, that being additional emission from additional engines.

Couldn't open Drawing File Y:\Jobs\0945- Withyhedge Landfill Site -
Overtight\Drawings\Drawings\DXFs\dx5.dxf

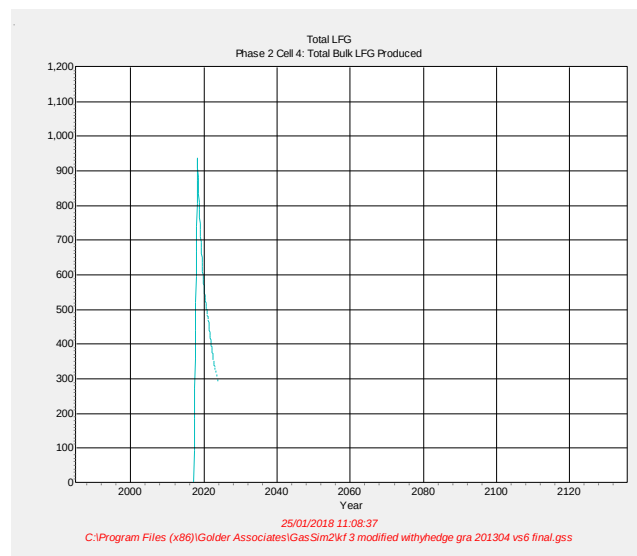
The Gassim generation curve demonstrates a 50%ile of a maximum of 2100m³ per hour and would be sufficient to run 3 one megawatt engines per hour. If we assume that the gas collection efficiency is 85% this comes to 1785m³ per hour potentially being delivered to the gas engines (3). With the gas collections system that has been installed it is expected that gas collection efficiency would be in the order of 95%.



Gas Generation Curve from model with modified inputs.



Peak Gas generation rate ~ 2,100m³/hour



Model output for Phase2, Cell 4 – modified to achieve sufficient gas to support 3x 1MW engines.

In the model, Phase 2, Cell 4 (2017) waste input rates have been modified upwards to generate the required volume of gas to the GUP. It has to be reiterated that fugitive surface emissions will not happen in that cell as it is already capped with HDPE and has 2 metres of clay soils overlying that cap. The main emissions of concern are based on an additional 1MW engine and massaged waste inputs. It is the impact from **potential** additional products of combustion that should be considered.

The model Outputs/Report can be seen below and the csv files for the Tier 2 Screening exercise are provided with the model in a digital form as a csv file which is attached. Tier 1, Tier 2, Global Impacts and lateral migration modes of the model demonstrate acceptable emissions from the site.

1.1 Report Context

- The operator of the installation is RML Limited.
- The Agent who completed this report is Exea Associates Limited.
- The proposed installation is in accordance with permit Reference. Waste types in that site are in accordance with that Permit.
- The site Conceptual Site Model Report can be seen in Table LFGRA 1 below.

1.2 Conceptual Site Model – Landfill Gas

This includes summary details cross referenced to in the existing site Permit and relating to the following:

Table LFGRA 1		
The proposed conceptual site model, which include all of the relevant source, pathway and receptor terms		
Source	Pathway	Receptors
Landfill gas Combustion	Dispersion	Rudbaxton Water Point 1 SAC
Landfill gas Combustion	Dispersion	Rudbaxton Water Point 2 SAC
Landfill gas Combustion	Dispersion	Rudbaxton Water Point 3 SAC
Landfill gas Combustion	Dispersion	Treffgarne Bridge Quarry SSSI
Landfill gas Combustion	Dispersion	Western Cleddau River SSSI

Sources

The proposed area for landfill can be seen in Diagram 1. The Gassim outputs for this area when artificially adjusted are in the order of 2000m³/hour in 2018.

Waste inputs are modelled using site specific data and have been modified to artificially generate enough gas to support 3x1 Mw engines. An existing 2000m³ flare already at the site are sufficient to deal with engine “down time”

Gas collection systems have already been expanded to accommodate any additional gas produced.

Pathways

Potential pathways to receptors including direct and indirect release (emission) points/areas for landfill gas and combustion product include lateral migration, fugitive emissions from the waste that can potentially move via the atmosphere, and combustion products from flare and engine that disperse via the atmosphere. Gas /leachate chambers can be a point source of emissions if gas if they are not sealed and if gas collection has not commenced. Gas carrier mains can also leak if damaged and require regular review during field balancing. Gas leaks in chambers/wells and carrier systems can be identified in review of gas monitoring data and consideration and manipulation of CH₄, CO₂, O₂ and balance gas.

Receptors

Potential receptors identified in the Gassim model “Screen shot” include:

Discrete Receptors

Identifier	Description	x co-ord [m]	y co-ord [m]
DR012	Rudbaxton Water Point 1 SAC	199471	220524
DR013	Rudbaxton Water Point 2 SAC	200255	221088
DR014	Rudbaxton Water Point 3 SAC	200868	221039
DR015	Treffgarne Bridge Quarry SSSI	199508	222108
DR016	Western Cleddau River SSSI	198732	220918

This model has outputs for gas migration, but gas migration is not the reason for carrying out this review.

The report considers the sensitivity of the above specific receptors and in terms of gas quality (trace components) gas generation rates, Tier 1 and Tier 2 assessments and looking at Environmental Assessment levels, odour thresholds and air quality standards. In essence, the model predicts there will be no exceedences. Trace component inputs are default except where site data has been obtained from the previous site infill where wastes are the same. Odour Units (**Predicted**) have been set at the defaults/ 100 based on the major odorous gases (Volatile Sulphur compounds and Ester) being default/500. These inputs are still considered to be very conservative because odour is normally associated with gas not being collected and areas without capping. The main objective is to assess emissions from the GUP where destruction rates at greater than 99%.

The potential impacts on each receptor has been assessed with priority on NO₂, NO_x, NO Hydrogen Sulphide, odour and Sulphur Dioxide, in addition trace components have also been considered at each receptor.

The potential gas volumes produced have been quantified using Gassim 2.5 and potential emissions to the environment assessed using Tier 1, Tier 2, Global Impact and Lateral Migration elements of the model.

2.0 LANDFILL GAS RISK ASSESSMENT

2.1 The Nature of the Landfill Gas Risk Assessment

A Gassim 2.5 model has been produced, based on 350,000m³ of non-hazardous wastes having already been deposited in the cell for re-circulation. As stated above the receptors identified have been reviewed with respect to air quality, odour and gas migration being the major components that may be sensitive. The model parameters used considered in this risk assessment consider both the 95%tile for dispersion and 50%tile generation rates and all assessments carried out are satisfactory.

Table LFGRA 3
The justification for the generated gases to be modelled
350,000m ³ of waste already been deposited in the re-circulation cell
Gases found in site sampling and laboratory analysis
Likelihood of combustion products to include NO ₂ , NO and NO _x , PM ₁₀ , Sulphur Dioxide
Generation of Feculant Volatile Sulphur Compounds (VSC'S) and other substances that may produce odour.
GWP of methane from the site

2.2 Proposed Assessment Scenarios

2.2.1 Lifecycle Phases

There is a single site life cycle that have been assessed:

1. Generation of sufficient landfill gas to sustain 3x1 Mw engines at the site. All other scenarios have already been considered in previous Gas Risk Assessment models.

Note: the primary reason for this assessment is to get permission to commence recirculation of leachate.

Table LFGRA 2	
The proposed assessment scenarios, include lifecycle phases and the possible accidents, and the conceptualisation of these scenarios (i.e. how certain inputs may change with time	
Normal Operation with GUP/Flare for 3x1 Mw engines.	This is an artificial circumstance modelled to accommodate an unsubstantiated estimate of gas generation.

2.2.2 Accidents and their Consequences

This normally include details relating to the following:

- A qualitative consideration of the impact of accidents and resulting damage to liner systems, landfill gas management and other engineering and management structures.
- The likelihood of the accidents occurring and the magnitude of the consequences of such accidents and failures.
- The justification for whether the specified accidents require quantitative assessment or not.
- The clear specification of additional scenarios that are to be given further quantitative analysis and the resultant implications for modelling.

The situation modelled is unlikely to be realized and in essence the outputs are considered to be unrealistic consequences, based on current research and independently peer reviewed publications, his type of review is good professional practice.

2.3 The Generated Gases to be Modelled

A full justification for the generated gases to be modelled is included:

Table LFGRA 4
The derivation and justification of the input parameters chosen
Trace gas components have been selected based on the Priority List and set at the default concentrations and measured gases falling within the Gassim 2.5 default inputs. In situations where there are very low concentrations of Feculant Sulphur compounds found via Laboratory analysis during annual testing for trace component gases
Surrogate substances such SO ₂ have been modelled using default values, but the level of Sulphide in the site gases is likely to be very low as per inputs and modelling is hugely conservative in that case. Modelling does not identify an issue.

Odour Units (Predicted) have used defaults/100 based on the concentration of odourous gases ground in adjacent areas where they have not shown to be an issue and where Hydrogen Sulphide is approximately 500x less than that seen in the defaults.

It is based on:

- The actual or potential presence of gases of concern.
- Consideration of the representative substances to be modelled and use of potential surrogate substances that could be used as indicators, including an assessment of their chemical and physical characteristics.
- The full justification of the final choice of substances.
- An assessment of the uncertainties associated with the choice of surrogate substances.

2.4 Numerical Modelling

2.4.1 Justification for Modelling Approach and Software

- The model selection is using Gassim 2.5 which is suitable to represent all of the considered scenarios (i.e. the different modelled phases of the lifecycle, potential impacts of accidents), gas generation, the dispersion of emissions and the environmental conditions. Seen in Table LFGRA2
- Modelling considers both the 95%tile and 50%tiles for gas production to accommodate both probabilistic and deterministic requirements for the assessment.
- Where it is determined that more detailed modelling is required, this has+ been carried out using Tier 2 assessment within the Gassim 2.5 model.

2.4.2 Model Parameterisation

Should include details of relating to the following:

These details can be seen in Table LFGRA 4

2.4.3 Sensitivity Analysis

- The inputs for Odour using default conditions was assessed and found to be problematic as the inputs are unrealistic. These were changed for a more sensible set of odour unit inputs based on the odorous components found at the adjacent site.
- A lowered set of odour units (predicted) have been used however the dilutions have been lowered such that there is a factor of safety based on real concentrations found on site versus defaults.
- The generation of sufficient gas in 2018 is sensitive to artificially loading waste inputs. Alteration of moisture contents in the cell do not generate sufficient gas to sustain 3x1Mw engines

Table LFGRA 5			
Trace Component	Concentration	Trace Component	Concentration
1, 1 - dichloroethane	<33ug/m ³	Chloroethane (vinyl chloride)	<33ug/m ³
1, 2 - dichloroethane	229ug/m ³	Dimethyl disulphate	786ug/m ³
1, 2 - dichloroethane	<33ug/m ³	Dimethyl sulphide	917ug/m ³
1, 1 - dichloroethane	190/ugm ³	Ethanal (acetaldehyde)	512ug/m ³
1, 3 - butadiene	<33ug/m ³	Ethanethiol	589ug/m ³
1 - butanethiol	<33ug/m ³	Ethyl butyrate	<82ug/m ³
1 - pentene	<33ug/m ³	Furan (1,4-epoxy-1,3 butadiene)	<33ug/m ³
1 - propanethiol	<33ug/m ³	Hydrogen Sulphide*	51,607ug/m ³
2 - butoxyl ethanol	<33ug/m ³	Methanal (formaldehyde)	128 ^(a) ug/m ³
Arsenic (as As)	<85ug/m ³	Methanethiol	<98ug/m ³
Benzene	3,602 ^(c) ug/m ³	Styrene	851ug/m ³
Butyric acid	<33ug/m ³	Tetrachloromethane	<33ug/m ³
Carbon disulphide	3,929 ^(a) ug/m ³	Toluene	13,424 ^(c) ug/m ³
Chloroethane	524ug/m ³	Trichloroethane	115ug/m ³
Trace Component	Concentration	Gassim Default values	
1, 1 – dichloroethane	<33ug/m ³	2.5 -3900ug/ m ³	
1, 2 – dichloroethane	229ug/m ³		
1, 2 – dichloroethane	<33ug/m ³		
1, 1 – dichloroethane	190ug/m ³		
1, 3 – butadiene	<33ug/m ³	1.0e-30-1.79mg/ m ³	
1 – butanethiol	<33ug/m ³	1E-30-1.00mg/ m ³	
1 – pentene	<33ug/m ³	33-12000ug/ m ³	
1 – propanethiol	<33ug/m ³	1e-33 -5.80mg/ m ³	
2 - butoxyl ethanol	<33ug/m ³	1e-33-3.66e+00mg/ m ³	
Arsenic (as As)	<85ug/m ³	1e-4 -0.1116 -0.43mg/ m ³	
Benzene	3,602 ^(c) ug/m ³	933-7300ug/m3	
Butyric acid	<33ug/m ³	1e-30- 1.75e+01mg/ m ³	
Carbon disulphide	3,929 ^(a) ug/m ³	0.52-170mg/ m ³	
Chloroethane	524ug/m ³	1.0e-30-5.30mg/ m ³	
Chloroethene (vinyl chloride)	<33ug/m ³	2.5-730000ug/ m ³	

2.4.4 Model Validation

This includes:

- The comparison of modelled output against what is observed in the field and represented within the conceptual landfill gas model (e.g. is the modelled gas generation compatible with that observed, etc.).
- Justification that the model provides a sufficiently adequate representation of reality.
- Both of these can be seen in Table LFGRA 6

Table LFGRA 6	
The model validation exercise, which compares the output against observed conditions	
The Gassim model has been artificially altered to achieve sufficient gas to service 3x1MW engines.	Industry “rule of thumb” is that 1 million tonnes of waste will produce 600m ³ of Landfill Gas per hour. Validation of this model cannot be achieved until recirculation has been carried out. There is no Research or independently peer-reviewed publications available to support the generation rates suggested.

2.5 Risks to the Environment and Human Health

The landfill gas risk assessment has addressed each of the considered scenarios (i.e. the different modelled phases of the lifecycle and the potential impact of accidents).

Model Outputs can be seen in Information provided in the csv files and other PDF outputs.

2.5.1 Landfill Gas Emissions

This includes details of:

- the estimated emissions from the site via the sub-surface, surface, gas engines and flares (including operational periods for the gas plant if appropriate).
- A gas generation profile forecast for the installation including uncertainty estimates.

2.5.2 Sub-surface Migration and Vegetation Stress

The model includes details of:

- Predicted leakage through proposed barriers -via the lateral migration module of the Gassim.
- Comparison of predicted levels with background concentrations and the corresponding environmental benchmarks via Tier 1 and Tier 2 assessment.

2.5.3 Atmospheric Dispersion and Odour

Include details of:

- comparisons of the Predicted Environmental Concentration (PEC) of each modelled substance releases to air with background concentrations and the corresponding environmental benchmarks (EAL or EQS). By way of the Tier 1 and Tier 2 modelling
- Appropriate stack heights for both utilisation plant and flares - this is included in the model input parameters .

2.5.4 Exposure

This includes details of:

- the estimates of concentration or doses to which the population may be exposed. These details can be seen in the outputs from Tier 2 Modelling

2.5.5 Global Atmospheric Impact

To include details of:

By treating an additional 300m³/hour of landfill gas via combustion there will be a saving of the equivalent of 16,438 tonnes of CO₂ per annum (having accounted for negative impacts of combustion such as CO₂, NO_x and CO). This methane would however be produced artificially to increase power outputs and there would not be an escape of Methane under usual model conditions (already modelled)

2.6 Landfill Gas Completion Criteria

This review does not include a Landfill completion review. This should have been Included in previous models for the site

3.0 LANDFILL GAS MANAGEMENT PLAN

The gas management plan must provide a framework for the management, monitoring and sampling of landfill gas is already agreed.

Table LFGRA 9
Internal, gas plant and external monitoring and sampling schedules
These are found in Gas Management Plan for the site.

Table LFGRA 10
The proposals for emission limits and landfill gas compliance level concentrations
Emission limits will be accordance with Standard Permit conditions and as modelled in the model input parameters – See Gas Management Plan also.

4.0 – Conclusions Compliance with the Landfill Directive

The conclusions to this exercise are that usually the aim of a Gas Risk Assessment is to estimate gas generation rates and emissions to allow a permit. In this case we have had to “massage” waste input rates (waste already deposited) to achieve sufficient gas production to sustain 3 x1MW engines.

The full Gassim2.5 model developed is not necessary and is mainly based on an unsubstantiated estimate in gas generation rates post -recirculation. Recirculation of leachate will undoubtedly increase gas generation and reactivate the waste, but Exea Associates have advised RML Limited that caution needs to be taken in accepting any estimations that are not backed up by Scientific support, academic research (independently peer reviewed papers) and industry acceptance. Using Gassim Lite the Landfill gas production rate for a cell with 350,000m³ (2010-2013 waste) where deposit occurs over 1 year would be approximately 200m³/ hour if the waste is “Average” moisture content. By increasing the moisture content to “Wet” gas generation increases to approximately 600m³/hr. The waste within the Withyhedge cell has been present for some time and is black, has already produced a significant volume of gas. This means there is a depleted source of cellulose and hemi-cellulose, so we would expect generation rates to be lower than with fresh waste, which means less than an uplift of 400m³/hour from the recirculation cell, this being the difference between average and wet. An uplift of 300m³/hour would generate an additional 500KW output from engines.

The existing permit conditions, Gassim model and GUP are sufficient to deal with the uplift in gas as the exiting export on the permit is 2.4MW per hour. Current power generation is 1.4 MW/hour. This means that recirculation should be allowed immediately based on the existing permit and without the additional modelling.

Table LFGRA 11
Compliance with the Landfill Directive
The site will be compliant with the Landfill Directive with emission of landfill gas at the boundary and at receptors being at appropriate levels.
The mode of gas collection and treatment will Engines first, followed by use of flares and will only cease when Environmental fluxes are at an appropriate level.

Appendix 1 – Gas Analysis for Withyhedge Landfill Site

Ener.G Natural Power Ltd
Trace Gas Analysis

R15084TG
March 2015

Withyhedge Landfill Site

A. Site Information

Sample Point Details		Sample Point Details	
Date	10/03/2015	Site	Withyhedge Landfill Site
Ambient Temperature	8°C	Atmospheric Pressure	1018mbar
Monitoring Organisation (s)	EnviroDat Ltd	Analytical Laboratory	SAL Ltd
Location of Sampling Point	After Blower, Inlet Line to Utilisation Plant	Area of Influence of collection system sampled	All capped areas of the site
Type of Sampling Point	Teflon Nipple	Temperature of gas	-
Vacuum on Sampling	None, Positive pressure	Type of waste	Domestic, Industrial, Commercial & Hazardous
		Age of Waste	-
Status of Gas System	Fully Operational, Steady State	Other	-

B. Preliminary Checks and Field Measurements

Parameter	Concentration	Units	Comments
Methane	47.2	%	-
Carbon Dioxide	28.9	%	-
Oxygen	0.4	%	-
Nitrogen	23.5	%	Assumed to be balance of gas

Ener.G Natural Power Ltd
Trace Gas Analysis

R15084TG
March 2015

C. Laboratory Analysis Results

Trace Component	CAS Number	Concentration in landfill gas sample	Units	Recommended Method (Y/N)	UKAS (Y/N)
1, 1 – dichloroethane	75-34-3	<33	µg/m ³	Y	Y
1, 2 – dichloroethane	107-06-2	229	µg/m ³	Y	N
1, 1 – dichloroethene	75-35-4	<33	µg/m ³	Y	Y
1, 2 – dichloroethene	540-59-0	190	µg/m ³	Y	Y
1, 3 – butadiene	106-99-0	<33	µg/m ³	Y	Y
1 – butanethiol	109-79-5	<33	µg/m ³	Y	Y
1 – pentene	109-67-1	<33	µg/m ³	Y	Y
1 – propanethiol	107-03-9	<33	µg/m ³	Y	N
2 – butoxyl ethanol	111-76-2	<33	µg/m ³	Y	N
Arsenic (as As)	7440-38-2	<85	µg/m ³	Y	Y
Benzene	71-43-2	3,602 ^(c)	µg/m ³	Y	N
Butyric acid	107-95-6	<33	µg/m ³	Y	N
Carbon disulphide	75-15-0	3,929 ^(a)	µg/m ³	Y	N
Chloroethane	75-00-3	524	µg/m ³	Y	N
Chloroethene (vinyl chloride)	75-01-4	<33	µg/m ³	Y	Y
Dimethyl disulphide	624-92-0	786	µg/m ³	Y	N
Dimethyl sulphide	75-18-3	917	µg/m ³	Y	Y
Ethanal (acetaldehyde)	75-07-0	512	µg/m ³	Y	N
Ethanethiol	75-08-1	589	µg/m ³	Y	N
Ethyl butyrate	105-54-4	<82	µg/m ³	Y	N
Furan (1,4-epoxy-1,3 butadiene)	110-00-9	<33	µg/m ³	Y	N
Hydrogen Sulphide*	7783-06-4	51,607	µg/m ³	Y	N
Methanal (formaldehyde)	50-00-0	128 ^(a)	µg/m ³	Y	N
Methanethiol	74-93-1	<98	µg/m ³	Y	N
Styrene	100-42-5	851	µg/m ³	Y	Y
Tetrachloromethane	56-23-5	<33	µg/m ³	Y	N
Toluene	108-88-3	13,424 ^(c)	µg/m ³	Y	N
Trichloroethene	79-01-6	115	µg/m ³	Y	Y

*H₂S value is equivalent to 34 ppm

^(a) – Results have been blank corrected

^(b) – Results should be considered a minimum due to detector saturation

^(c) – Results should be viewed with caution due to being outside of the instrument calibration range

Reference to UKAS (final column) relates to the accreditation status of the analysis only, sampling is covered under EnviroDat Accreditation scope.

Recirculation Calculator

Input **Green**

Site Specifics

Working days

5 days

Working hours

24 hrs

Wetted Width

15 m

Spacing

20 m

Coverage

12,000 m²

Depth

20 m

Deadzone

1 m

Leachate Level

1 m

Area

216,000.00 m³

Compaction ratio

1.2 t/m

Tonnes

259,200.00 t

Capacity (low)

44,064.00 m³

Capacity (med)

64,800.00 m³

Capacity (high)

88,128.00 m³

Initial Reach

121,500 m³

Proposed Infrastructure

Recirculation

30

Extraction

0

Pump Loops

1

Generators

2

Pump flow rate

4.50 m³/h

Recommended Infrastructure

Recirculation

30

Extraction

0

Pump Loops

1

Generators

2

Pump flow rate

4.00 m³/h

Annual

35,000 m³

Daily

95.89 m³

Max Flow

4.50 m³/h

Recirculation Strategy

Target annual

25,000 m³

Target daily

95.89 m³

Target individual

3.20 m³

Months

Years

Duration (0.17)

21.44

1.79

Duration (0.25)

31.54

2.63

Duration (0.37)

42.89

3.57

Capable annual

28,080 m³

Capable daily

108.00 m³

Capable individual

3.60 m³

Months

Years

Duration (0.17)

19.1

1.59

Duration (0.25)

28.1

2.34

Duration (0.37)

38.2

3.18

System Performance

25,000

28,080

Target annual

Capable annual



Absorption Duration (Years)

