Caulmert Limited

Engineering, Environmental & Planning
Consultancy Services

Standard Closure Plan

Flintshire County Council Waste Management Services

Standard Landfill Site

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CLOSURE PLAN

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1 PRELIMINARIES

1.1 Introduction

1.1.1 Caulmert Ltd has been appointed by Flintshire County Council Waste Management Services (FCC) to prepare a Closure Plan for the Standard Landfill facility, near Buckley, Flintshire.

1.1.2 This Closure Plan relates to the requirements of the Environmental Permit (EPR), ref. EPR/BP3390VA (previously EAWML 37073) originally issued to AD Waste Ltd, then transferred to Flintshire County Council for Standard Landfill.

1.1.3 The Site closed for the disposal of waste by landfill in 2005. Restoration was completed in 2006.

1.2 Site Location

1.2.1 The site is located approximately 1 km to the northeast of Buckley town centre. The National Grid Reference (NGR) of the centre of the landfill is approximately SJ 291 651.

1.2.2 The site is located on a former opencast coal mine. To the north the site is bounded by a woodland and open ground within the Buckley Claypits and Commons SSSI. The A55 road is located some 100 m northeast of the site. Further to the west is the Etna Country Park which has historically been used for landfilling of inert, industrial, commercial, household and special waste. Woodland (SSSI) borders the site along its south-eastern side, beyond which approximately 25 residential properties are located between the site and Burntwood Road, within 250 m of the site. The Spencer Industrial Estate is located immediately adjacent to the southwestern site boundary. It is understood that the industrial estate is located on made ground comprising colliery spoil and that there were gas emissions known to occur from these deposits during the early phase of waste disposal at Standard Landfill.

1.2.3 Further to the south, beyond Mount Pleasant Road, is the Drury Lane Industrial Estate. This industrial estate is also located on an area formerly used for waste disposal (inert waste only).

1.3 Area of Closure

1.3.1 The area of closure that is subject to this closure plan is shown on drawing 3031-CAU-XX-XX-DR-G-3801.

1.4 Environmental Setting

Geology

1.4.1 British Geological Survey (BGS) Geological Map Sheet 108 (Flint) indicates that the site and surrounding land are located on Middle Coal Measures strata of Upper Carboniferous age (Westphalian) and form part of the South Flintshire Coalfield. The strata comprise Interbedded mudstones, siltstones and sandstones with coals and seatearths.

1.4.2 The Middle Coal Measures sequence in the vicinity of the site is likely to be up to around 150 m in vertical thickness and is underlain successively by Lower Coal Measures (of similar lithology and thickness), Millstone Grit (sandstones of more than 500 m thickness) and Carboniferous Limestone strata (argillaceous limestones, calcareous sandstones and mudstones).

1.4.3 The site is located on thin Boulder Clay deposits, of up to around 6 m thickness, overlying Middle Coal Measures strata between the Crank and Black Bed coal seams in the geological sequence. BGS Map 108 indicates that the bedrock in the vicinity of the site, and across the wider region, is covered with a laterally extensive deposit of glacial till (Boulder Clay) of variable thickness and composition. Boulder Clay deposits are unsorted and, although generally clay-rich, can contain sand beds or lenses and larger rock fragments

Hydrogeology

1.4.4 The geological strata beneath the site (Middle Coal Measures) are classified by Natural Resources Wales (NRW) as Minor Aquifer Low, in terms of groundwater vulnerability.

1.4.5 There are no groundwater abstractions or Source Protection Zones in the vicinity of the site.

Surface waters

1.4.6 There is a stream located north of the site, flowing north-eastwards, past location of surface water treatment lagoons. Its spring is 100 m to the northwest. A second stream and spring are present 200 m to the northwest, flowing roughly parallel to the closer stream. The River Dee is 5 km due northeast.

1.4.7 The springs located some 100-200 m west/northwest of the site are likely to be associated with a perched water table contained within an outcrop of sandstone (bedrock) in an adjacent fault-bounded block. The resultant stream flows north eastwards across Boulder Clay and mudstone strata as overland flow, hydraulically isolated from local groundwater. The monitoring locations SW1, SW2 and SW4 are largely up gradient of site. SW5 is located within the settlement lagoons to the north of the landfill.

1.4.8 NRW's indicative flood maps show that the site is not within a floodplain.

1.5 Site development history

1.5.1 Standard Landfill Site was developed in the void created by a former open cast coal mine extending to approximately 8 ha. The site was excavated to a depth of approximately 112 mAOD (metres Above Ordnance Datum). The restored landform is a broad dome with a maximum elevation of approximately 154 mAOD in the centre of the site, falling to approximately 125 to 130 mAOD on the northwest and northeast boundaries; approximately 130 to 137 mAOD on the southeast boundary towards Burntwood Road, and approximately 127 to 140 mAOD on the southwest boundary in proximity to the industrial estate.

1.5.2 The site area covers approximately 13.3ha and the total waste accepted was approximately 1,437,330 tonnes. The site is classified as a non-hazardous landfill and accepted predominantly household waste from local authorities in Flintshire.

1.5.3 Planning permission reference 037657, to authorise the continuation of waste disposal at the site was granted in June 2005.

1.5.4 Standard Landfill was licensed prior to the introduction of the PPC Regulations and EPR Regulations. Waste Management License (WML 37073) was issued in January 1993 to AD Waste. The WML was transferred to Flintshire County Council via Transfer Notice Number EPR/BP3390VA/T001 on the 25th September 2009.

1.5.5 The Site closed for the disposal of waste by landfill in 2005. Restoration was completed in 2006. The site fell under the Landfill Directive transitional arrangements and is therefore regulated as a waste operation having never operated under a permit compliant with the Landfill Directive requirements.

1.5.6 The site currently operates under EPR Permit BP3390VA.

1.5.7 The weighbridge and some of the associated hard standing areas remain. Located within this is an area for leachate tankers to load and a leachate sump to collect any spillages. There is a Materials Recycling Facility (MRF) located off site, to the southwest of the landfill area.

1.5.8 Cells 1, 2, 3, 4, 2a, 3a, 5 and 6 have been restored to grassland. Landfill cap placement was completed in 2005 using engineered clay and a 1 mm thick welded, flexible low density poly-ethylene (LDPE) membrane. The placement of the landfill cap was supervised by a qualified CQA engineer and all construction quality assurance reports were submitted to the Environment Agency (now Natural Resources Wales (NRW)) in accordance with the WML.

1.5.9 The gas utilisation scheme includes an environmental compound that houses the electricity generating engine and a backup flare to be used in the event of the failure of the engine.

1.5.10 The electricity generating engine at the site is a Caterpillar G3516 which was installed by Finning (UK) Limited. It is designed to meet current emissions standards. The engine was initially rated at 1025 kW, but is currently de-rated to approximately 650 KW.

1.5.11 Current activities at the site relate to on-going maintenance, leachate and landfill gas management and environmental monitoring. Leachate is currently managed by tankering off site for disposal at another nearby FCC owned site; Brookhill Landfill.

1.5.12 This Closure Plan will cover the entire area covered by the landfill, as defined by the boundary of landfill according to the WML, but excludes activities carried out within the Household Waste Recycling centre which is regulated by a separate Environmental Permit. The boundary of the area covered by this Closure Plan is indicated on Drawing 3031-CAU-XX-XX-DR-G-3801.

1.6 Staffing/Certificate of Technically Competent Persons

1.6.1 Control of the activities that are authorised by the Environmental Permit will be carried out by a suitably qualified COTC manager.

1.6.2 The designated Technically Competent Persons are Paul Murphy and Ruth Cartwright. A copy of their certificates are contained within Appendix A.

1.6.3 Any changes in the technically competent management of the site, including the name of any incoming person, together with evidence that such person has the required technical competence shall be submitted to the NRW in writing within 5 working days of the change in management.

1.7 Amendment Procedure

1.7.1 FCC shall give notice to NRW in writing of any changes to the Closure Plan. Implementation of any changes will only be put into effect and incorporated into the Closure Plan when approval of a risk assessed approach and subsequent approval of the proposal have been received in writing, where necessary, from NRW.

1.8 General

1.8.1 There is little remaining site infrastructure on the landfill area other than that associated with landfill gas and leachate management. A solar array was added in 2016 in accordance with Planning Application reference 054630.

1.8.2 The fence surrounding the landfill gas utilisation compound and solar array will be inspected and maintained and any faults are reported. Arrangements to conduct repairs are made and the details are recorded in the Site Diary. Any faults, which are likely to jeopardise the security of the site, are given immediate priority.

2 CLOSURE MANAGEMENT PLAN

2.1 Restoration

2.1.1 The proposed after use of the site comprises a solar farm and amenity use, with some hedgerow and tree planting. Final as-built restoration is shown on Drawing 3031-CAU-XX-XX-DR-G-3800.

2.2 Landfill Engineering

2.2.1 The site comprises eight landfill cells (Cells 1, 2, 3, 4, 2a, 3a, 5 and 6). Cells 1 to 4 form the deepest part of the site and are not separated by inter-cell bunds, therefore they effectively form one large landfill cell in the base of the site. These cells were lined with compacted clay of 1 m thickness, although not subject to construction quality assurance (CQA) supervision.

2.2.2 Cells 2a, 3a, 5 and 6 have been lined on their perimeter side-slopes with 1 m of compacted clay. Engineering of these cells was subject to CQA supervision, the last of which (Cell 6) was completed in 1996.

2.2.3 The exact elevation of the base of the landfill (base of Cells 1 to 4) is not known, however correlation of the observed depth of leachate chamber LC2.1 (31 mbgl) with the surveyed ground level recorded in 2005 (143 mAOD) indicates that the basal elevation of the landfill at this location may be in the order of 112 mAOD.

2.2.4 No basal leachate drainage layer has been constructed at the site, although a 200 mm thick drainage blanket with associated drainage pipework was placed above the side-slope liner in Cells 5 and 6.

2.2.5 Landfill cap placement was completed in 2005 using engineered clay and a 1 mm thick welded, flexible low density poly-ethylene (LDPE) membrane. The placement of the landfill cap was supervised by a qualified CQA engineer and all construction quality assurance reports were submitted to the Environment Agency (now Natural Resources Wales (NRW)) in accordance with the WML.

2.3 Stability of the Landfill Site

General

2.3.1 A requirement of closure is to demonstrate that the waste mass is stable, that there will be no slippage and that any movement due to settlement will not have an impact on the site's infrastructure.

Previous Reports

2.3.2 Numerous stability risk assessments (SRA) have been carried out and include the following;

- Stability Risk Assessment - EDGE Consultants UK Ltd in September 2003 as documented within the closure report ref. WML 37073.
- Stability Report for the capping works by Egniol Ltd in February 2005, ref. Stability Assessment ver 1.0.doc.
- Stability Risk Assessment Report carried out by TerraConsult (0987/SRA001) submitted June 2011.

2.3.3 An update of the 2011 TerraConsult SRA report, (dated July 2012 1588/R/001-1) has been provided. The updated report was undertaken in response to comments made by Environment Agency Wales and is herein referred to.

2.3.4 The updated SRA focussed on two elements; waste mass (global) stability and the capping (veneer) stability. The updated report justifies the modelling approach and provides parameters, calculations and analyses outputs used for waste mass stability. However, the report does not discuss the stability of the capping system and only refers back to analyses carried out in the previous (2011) report.

2.3.5 The report states that both the waste mass and capping systems are stable in the long-term, however it is noted that signs of distress in the form of a tension crack, were visible during a site inspection (4th May 2012) along the southern flank. The report recommended that the tension crack be compacted and sealed with bentonite pellets as a matter of urgency. It is understood that this was carried out. The site has since been re-contoured.

Review

2.3.6 An up to date topographical survey of the site has been provided, dated May 2017.

2.3.7 Pre-settlement (restoration) contours or as-built surveys of the capping works, have not been provided so a comparison of the proposed restoration (or as-built) contours against the existing topographical survey could not be undertaken.

2.3.8 The Egniol SRA (2005) and CQA validation report (2006) both reference the final slopes at between 1V:3.5H to 1V:8H with the capping system comprising an LLDPE textured

geomembrane on gradients between 1V:3.5H and 1V:8H and a smooth LLDPE geomembrane on gradients of shallower than 1V:8H.

2.3.9 To assess the long term stability a review of the existing slopes was carried out using the topographical survey (dated May 2017), presented in Drawing 3037-CAU-XX-XX-DR-G-3800.

2.3.10 An assessment of the six steepest slope sections was carried out across the site. Overall the majority of the existing slopes are at gradients less than 1V:3.5H though localised gradients at 1V:2.2H and 1V:2.7H were present over short distances on some slopes (these localised sections being steeper than those outlined in the Egniol SRA and CQA validation reports).

2.3.11 Whilst these localised steeper sections are unlikely to adversely affect the stability if the capping system installed, a stability check has been carried out on slopes with gradients of 1V:2H and 1V:3H. Using the same parameters as those referenced in the Egniol SRA report, the results show that the capping system is stable at gradients of 1V:2H and 1V:3H. The results of the stability check are summarised in Table 2.1 below and the outputs are presented in Appendix 2.

Table 2.1: Stability results

Interface	Slope Gradient	Interface Shear Strength (Peak values) Parameters				
		c' (kPa)	ϕ°	γ (kN/m^3)	R_u	FOS
Subgrade or Protection Layer / Textured Geomembrane	1V:2H	7	27	18	0	1.89
					0.2	1.63
					0.25	1.57
	1V:3H				0	2.76
					0.2	2.42
					0.25	2.33

Parameters selected from Egniol SRA (2005); based on Dixon and Jones 1998

2.3.12 On the basis of the results of the stability check the existing capped slopes exhibit a factor of safety (Fs) above 1.3 which is considered to be stable in the long term.

2.4 Monitoring of Waste Mass

2.4.1 Annual topographical surveys as per sections 3.1 and 5.1 will verify the stability of the landfill over the aftercare period and annual inspections will check the condition of the restored surface. In the event that topographical surveys show evidence of significant settlement or slippage, an investigation into the cause will be instigated and the findings reported to NRW.

2.4.2 In addition, visual inspections during routine environmental monitoring visits will be undertaken for:

- Evidence of instability or movement in the capping system;

- Evidence of differential settlement causing depressions in the restored landform, cracks in the capping system; and
- Evidence of sudden drop in leachate levels.
- Initial onset of movement identified by the emissions of hydrocarbons detected by the FID walkover survey.
- If there is evidence of movement in the waste mass e.g. from regular topographical surveys a competent engineer will review the data and inspect the affected area. The action taken will depend upon the severity of the movement, the timescales over which the unstable mass will remain unsupported and the consequences of possible failure. The need and type of remedial action will be reported to and discussed with NRW and Planning Authority if relevant.

2.4.3 Appropriate action will include, but not be limited to:

- The repair of damaged infrastructure. Refurbishment works to the leachate and gas system, on an as required basis;
- Importation and placement of soils for infilling of depressions to ensure shedding of surface waters into the drainage ditches;
- The de-silting of any internal surface water system;
- In the event of surface cracking occurring, reinstatement of the affected area to the correct profile;
- Replacement of drainage channels to ensured continuing integrity of surface water drainage;
- Review of design to accommodate predicted differential settlement by locally strengthening cap, providing additional thickness of capping materials or incorporating irregular edges and boundaries to compensate for predicted settlement differentials;
- Localised removal of capping layers, surcharging with soils and replacement of cap under appropriate CQA procedures if deemed necessary;
- Refurbishment works to the leachate and gas system, on an as required basis;
- Maintenance of any planted shrub species will be undertaken on an as required basis, in accordance with accepted good practice;
- The situation will continue to be monitored through regular visual inspections and topographical surveys to be recorded on the Closure ProForma.

2.5 Landfill Gas Management and Monitoring

Management

2.5.1 Standard Landfill is currently subject to an Environmental Permit, having originally operated under a Waste Management License. A Landfill Gas Management Plan[1] (Appendix 4) has been implemented at the site to better manage the gas field, reduce odour and prevent gas migration. The responsibilities for the delivery of the landfill gas management plan for

[1] 1240.4. FCC. JDM.ÅKS.A2 Landfill Gas Management Plan. Caulmert Ltd. March 2012.

Standard Landfill Site lie with the Landfill Manager, and the Monitoring Technical Officer. Landfill Gas will continue to be managed and monitored until Permit Surrender.

2.5.2 The role of the Landfill Manager is to maintain contact with the relevant NRW officer and to schedule the relevant site works and report production.

2.5.3 The role of the Monitoring Technical Officer is to schedule and conduct the site monitoring exercises, and report exceedances of site trigger levels to the relevant manager.

2.5.4 The landfill gas management system will be subject to an operational, preventative maintenance and servicing programme in accordance with the manufacturer's recommendations. Procedures detailing all the operational and maintenance requirements for the permanent gas flare will be retained within the gas management compound or other suitable central facility. Personnel responsible for the operation and maintenance of the gas management system will be trained and fully conversant with the operational procedures and safety and maintenance programmes.

2.5.5 The integrity of the gas system will be inspected during the routine monitoring and any identified problems affecting the operation of the system will be remedied to ensure continued effective control of landfill gas. Bi-annual Gas well condition surveys are also undertaken to ensure sub-surface conditions do not deviate from design.

2.5.6 The results of the routine monitoring of gas quality, flow and pressure will be used to adjust and 'balance' the gas system, in order to optimise the extraction and control of the gas. This will be achieved by manually adjusting the control valves and the suction that is applied to individual wells or groups of wells, and thereby ensure equilibrium with gas generation rates within the site.

2.5.7 The extraction system is designed and configured to enable individual parts of the gas field to be isolated and controlled. This enables appropriate adjustments to be made to individual wells or groups of wells to ensure migration control is optimised.

Monitoring

2.5.8 Routine landfill gas monitoring is carried out on a quarterly basis at all perimeter boreholes in accordance with the requirements of the EP. Landfill gas migration results are statistically analysed and reported on a quarterly basis and in greater detail on an annual basis, to identify any trends in methane and carbon dioxide, in comparison to the trigger limits as outlined in the Landfill Gas Management Plan and presented in Table 2.2.

Table 2.2 - In-Waste Landfill Gas Monitoring Compliance Limits

Location	Methane (%v/v)	Carbon Dioxide (%v/v)
	Limit	Limit
BH 1	1	5.4
BH 1.1	1	5.4
BH 2.0	1	7.1
BH 2.1	1	7.6
BH 2.2	1	5.8
BH 3.0	1	6.7
BH 3.1	1	7.8
BH 4.0	1	10.7
BH 4.1	1	7.1
BH 4.2	1	8.6
BH 5.0	1	19.4
BH 5.1	1	5.8
BH 5.2	1	9.6
BH 5.3	1	6
BH 5.4	1	16
BH 5.5	1	17.1
BH 5.7	1	7.1
BH 6.0	1	8.9
BH 6.1	1	3.7
BH 6.2	1	6.1
BH 6.3	1	8.2
BH 7.0	1	6.2
BH 7.1	1	5.5
BH 12	1	6.5
BH 13	1	5.2
BH 15	1	8.3
BH 16	1	3
BH 22	1	3.1

2.5.9 The gas field at Standard is currently monitored and balanced on a monthly basis. Methane, carbon dioxide, oxygen, balance, relative pressure, hydrogen sulphide and carbon monoxide will be recorded on each visit in accordance with the recommendations of LFGTN 03[2].

2.5.10 It is proposed that the gas field monitoring and balancing is conducted on a quarterly basis, as detailed in Table 2.3 below.

Table 2.3 - In-Waste Landfill Gas Monitoring

Test type and monitoring points	Frequency	Parameters	Unit	Other Specifications
All installed gas extraction wells	Quarterly	CH_4, CO_2, O_2 CO H_2S Relative Pressure	% v/v ppm ppm mb	Where the O_2 level exceeds 5% or where the addition of CO_2 and CH_4 percentages is less than 80% the extraction from the gas well shall be reduced and an assessment of air ingress into the system shall be undertaken.

[2] LFTGN03 'Guidance on the management of landfill gas' Environment Agency. June 2014

		Gas flow rate or suction Balance	m^3/h or mb %	Where the concentration of CO exceeds 100ppm then further investigation shall be undertaken.
Input to gas plant	Annually	Trace Gas Analysis	-	-

NB Annual monitoring is only required for the flare when the flare operates for greater than 10% of the time in any 12 month period. NMVOCs have been excluded as these are no longer specified for emission monitoring in Permits.

2.5.11 On a quarterly basis, the gas pipelines, wellheads, manifolds and condensate knockout systems shall be checked by the monitoring technician for the following:

- Wellhead damage;
- Settlement, which may affect wellhead connections and pipework falls;
- Condensate, which may block pipelines or restrict flow;
- Integrity of couplings and connections;
- Pipework damage and leaks; and
- Functioning of condensate pumping systems.

2.5.12 A Walkover FID Survey to monitor for surface emissions will be carried out annually using a Calibrated Gas-Tec flame Ionisation Detector or similar, in accordance with LFTGN 07[3]. The capped surface will be surveyed on lines at 50 m intervals at a distance of not exceeding 5 cm from the caps surface as well as around the base and headworks of any protuberances through the cap.

2.5.13 The monitoring of the gas plant emissions to air is designed in accordance with Environment Agency Technical Guidance Note LFTGN 08[4]. The landfill engine will be monitored for the presence and concentrations of nitrogen oxides, carbon monoxide, total volatile organic compounds (VOC's) and total non-methane volatile organic compounds (NMVOC's).

2.5.14 The engine will be monitored for the presence and concentrations of the parameters, listed in Table 2.4 below:

[3] LFTGN07 'Guidance on monitoring landfill gas surface emissions'. Environment Agency. June 2014
[4] LFTGN08 'Guidance for monitoring landfill gas engine emissions'. Environment Agency. June 2014

Table 2.4: Engine Emissions Sampling Protocol

Parameter	Monitoring frequency	Emissions limits, mg/m^3	Monitoring method
		Engine	
Oxides of Nitrogen (as NO_2)	Annually	650	Extractive sampling & Chemiluminescence (ISO 10849:1996)
Carbon Monoxide (CO)	Annually	1500	Extractive sampling & Non-dispersive Infra-Red Analysis (ISO 12039:2002)
Total Volatile Organic Compounds (VOCs)	Annually	1750	Extractive sampling and FID analysis (BS EN 12619:1999, BS EN 13526:2002)
Total Non-Methane Volatile Organic Compounds (NMVOCs)	Annually	150	Extractive sampling onto sorbent, thermal desorption, analysis by GC (BS EN 13649:2002)

2.5.15 At present the use of the backup flare is limited to short periods of time – typically less than 10% of available hours annually. For this reason routine flare monitoring is not currently undertaken.

2.5.16 When gas utilisation is no longer feasible, during the latter stages of gas production, gas collected via the gas extraction field will be combusted using a landfill gas flare, or suitable gas control system. Any specification for a new system will be discussed with NRW prior to installation.

2.5.17 If the flare is operational for more than 10% of time, flare monitoring will be undertaken on an annual basis in accordance with the requirements of Environment Agency Technical Guidance Note LFTGN 05[5], as detailed below.

2.5.18 The flare will be monitored for the presence and concentrations of the parameters, listed in Table 2.5 below:

[5] LFTGN 05 'Guidance for monitoring enclosed landfill gas flares'. Environment Agency. June 2014.

Table 2.5: Flare Emissions Sampling Protocol

Parameter	Monitoring frequency	Emissions limits, mg/m^3	Monitoring method
		Flare	
Oxides of Nitrogen (as NO_2)	Annually	150	Extractive sampling & Chemiluminescence (ISO 10849:1996)
Carbon Monoxide (CO)	Annually	50	Extractive sampling & Non-dispersive Infra-Red Analysis (ISO 12039:2002)
Total Volatile Organic Compounds (VOCs)	Annually	10	Extractive sampling and FID analysis (BS EN 12619:1999, BS EN 13526:2002)
Total Non-Methane Volatile Organic Compounds (NMVOCs)	Annually	5	Extractive sampling onto sorbent, thermal desorption, analysis by GC (BS EN 13649:2002)

Reporting

2.5.19 The following compliance monitoring data will be reported from Standard Landfill.

2.5.20 Monitoring data shall include:

- Specified details such as date, time, location, personnel undertaking monitoring and equipment used;
- Weather conditions incl. barometric pressure;
- Determinants monitored;
- Results of measurements (with error limits);
- Interpretation and review of results; and
- Validation of accuracy and validity of results.

2.5.21 All monitoring result recorded will be reported to NRW within 28 days of the end of the reporting period. A review of the landfill site and all monitoring data will be included in the annual environmental report for the site. This will include analysis of the data to highlight any trends, and details of any proposed remedial actions in the event of any adverse trends or data. It shall be submitted no later than 31st January after the end of the annual period. Additionally, a review of monitoring results for landfill gas and trigger levels will be produced on a 3 month basis. A summary report of this review will be sent to NRW within 1 month of the end of each 3 month period.

Management Objectives.

2.5.22 The monitoring and management of landfill gas will continue until it is demonstrated that no discernible landfill gas is being produced.

2.6 Groundwater Monitoring

Management

2.6.1 The Groundwater Management Plan[6] (Appendix 5) specifies management responsibilities, procedures and monitoring requirements for Standard Landfill to identify any potential pollution from landfill leachate.

2.6.2 There are seven boreholes installed within the limestone aquifer around the perimeter of the site that are used to monitor groundwater quality and groundwater levels. The boreholes are GW1, GW2, GW3, GW4R, GW5, GW6 and GW7.

2.6.3 Groundwater monitoring locations are presented on the enclosed Environmental Monitoring Plan contained with drawing 0987/1/002.

2.6.4 The groundwater infrastructure inspection and monitoring programme along with the collected data are subject to quarterly review throughout the post-closure aftercare period of the installation.

2.6.5 Should the groundwater monitoring point become damaged to such an extent that groundwater levels and quality cannot be recorded; alternative monitoring locations will be proposed and agreed with NRW. The nature and location of any replacement well, as well as the installation methods to be used, would be submitted to NRW for approval, prior to any works being undertaken.

Monitoring

2.6.6 Samples are taken monthly from the 7 groundwater boreholes and these are sent to an accredited laboratory for analysis in accordance with the EP. Groundwater levels and quality are reported as agreed with NRW, displayed in Table 2.6 below.

[6] 1629.10.FCC.JDM. ÅKS.A0 Groundwater Management and Monitoring Plan. Caulmert Ltd. July 2013.

Table 2.6 – Current Groundwater Monitoring Requirements

Test type and monitoring points	Total	Frequency	Suite	Unit	Compliance Limit
Groundwater Levels					
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Quarterly	Dip to liquid	mBGL	N/A
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Annually	Dip to base	mBGL	N/A
Groundwater Quality					
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Quarterly	NH_4-N		6.4 mg/l*
			Ca, Cl^-, As, Cd, Cu, Fe, Pb, Mg, Hg, Ni, Zn, Alkalinity ($CaCO_3$), K, Na, Nitrate, Nitrite, SO_4, TON, TOC, total phenols, total cyanide, BOD and COD	mg/l	N/A
			pH	-	N/A
		Annually	Hazardous Substances Suite	µg/l	N/A

***NH_4-N compliance limit applies to downgradient boreholes; GW2 and GW3 only**

2.6.7 In accordance with the Updated Groundwater Conceptual Model[7], the proposed groundwater monitoring during the aftercare period, it is suggested that this monitoring schedule is continued, with reassessment of trigger limits periodically.

Management Objectives

2.6.8 The Site is subject to a six-yearly Hydrological Risk Assessment (HRA), where the groundwater contours and quality trends are critically reviewed alongside the leachate levels and quality. The frequency for groundwater monitoring shall be reviewed as part of every review.

2.6.9 If stable conditions are present, the frequency of inspection and or number of analysed determinants may be reduced following discussion and consultation with NRW.

2.6.10 Monitoring of the site will continue until it can be demonstrated that there is no discernible impact from the site in order to support a Permit surrender application.

[7] 1629.11.FCC.JDM. ÅKS.A0 Update to Groundwater Conceptual Model. Caulmert Ltd. July 2013.

2.7 Surface Water Management and Monitoring

Management

2.7.1 The River Dee flows from south east to north-west approximately 5km from Standard Landfill. Springs flow in a north easterly direction, past the northern boundary of the Site, towards the River Dee.

2.7.2 Surface water collection, treatment and discharge is managed in accordance with the Surface Water Management and Monitoring Plan[8] (Appendix 6). A series of ponds and settlement lagoons are located north of the Site to manage surface water runoff, prior to discharge. A collection drain surrounds Standard Landfill to collect all runoff rainwater to discharge into the first of the lagoons via a series of drainage channels and sluices. This runoff is then discharged (under Consent) to the stream located to the north of the site.

Monitoring

2.7.3 The surface water quality is monitored routinely at four locations (SW1, SW2, SW4 and SW5) along the stream that accepts the Site's discharged rainwater runoff. These locations are shown on Drawing 0987/1/002 in Appendix 1.

2.7.4 The monitoring locations SW1, SW2 and SW4 are mostly up-gradient of the landfill, while SW5 is monitored at the settlement lagoon prior to discharge. As agreed with NRW in the letter dated May 5th 2017[9], SW1 and SW2 no longer require monitoring as they are not connected to the ground or surface water and are not being influenced by the Site.

2.7.5 The parameters currently monitored at the surface water locations are summarised in Table 2.7. SW4 and SW5 are frequently dry, and are only sampled when sufficient water is available.

[8] 987/R/002/1 Surface Water Management and Monitoring Plan. TerraConsult. July 2012
[9] NEM4/37073/ML/01 Environment Agency Wales Letter; 14th November 2012

Table 2.7 –Surface Water Monitoring

Monitoring point	Parameter	Monitoring frequency	Compliance Limit	Other specifications
SW4 & SW5	Ammoniacal nitrogen BOD Calcium Chloride COD Electrical Conductivity Iron (dissolved) Magnesium (dissolved) Nitrate pH Potassium (dissolved) Sodium (dissolved) Sulphate Suspended Solids Temperature TON Total Alkalinity as $CaCO_3$	Quarterly	Ammoniacal Nitrogen 1 mg/l+ Chloride 105 mg/l+	As specified in Environment Agency Guidance TGN02 'Monitoring of Landfill Leachate, Groundwater and Surface Water' (February 2003) and Horizontal Guidance Note H1 – Environmental Risk Assessment for permits, Annex J, version 2.1, December 2011) & in accordance with the Surface Water Management and Monitoring Plan

+ Compliance Limit only applies to SW5

Reporting

2.7.6 The following compliance monitoring data will be reported from Standard Landfill.

2.7.7 Monitoring data shall include:

- Specified details such as date, time, location, personnel undertaking monitoring and equipment used;
- Determinants monitored;
- Results of measurements (with error limits);
- Interpretation and review of results; and
- Validation of accuracy and validity of results.

2.7.8 All monitoring result recorded will be reported to NRW within 28 days of the end of the reporting period. A review of the landfill site and all monitoring data will be included in the annual environmental report for the site. This will include analysis of the data to highlight any trends, and details of any proposed remedial actions in the event of any adverse trends or data. It shall be submitted no later than 31st January after the end of the annual period. Additionally, a review of monitoring results for surface water and trigger levels will be produced on a 3 month basis. A summary report of this review will be sent to NRW within 1 month of the end of each 3 month period.

Management Objectives

2.7.9 Monitoring of the site will continue until it can be demonstrated that there is no discernible impact from the site in order to support a Permit surrender application.

2.8 Leachate Management and Monitoring

Management

2.8.1 Due to the age and types of waste accepted at the landfill the will produce leachate for a number of years which will require ongoing management. This will be conducted in accordance with the Leachate Management Plan[10] (Appendix 7).

2.8.2 Leachate extraction wells have been installed into the waste mass, and levels across the site are monitored in Sumps LC2, LC3, LC4, LC7, S1, S2, and S3.

2.8.3 Leachate levels and quality are currently monitored at each leachate sump as detailed in Tables 2.8 and 2.9.

Table 2.8 - Leachate Level Monitoring

Test type and monitoring points	Total	Frequency	Compliance Limit	Suite	Unit
Leachate levels					
LC2, LC3, LC4, LC7, S1, S2, S3, SSR5 and SSR6	9	Quarterly	2 m above base of cell	Dip to liquid	mBGL
LC2, LC3, LC4, LC7, S1, S2, S3, SSR5 and SSR6	9	Annually	-	Dip to base	mBGL

Table 2.9 – Leachate Quality Monitoring

Test type and monitoring points	Total	Frequency	Suite	Unit
Leachate quality				
LC2, LC3, LC4, LC7, S1, S2, S3, SSR5 and SSR6	9	Quarterly	Alkalinity, ammoniacal nitrogen, BOD, COD, chloride, electrical conductivity, magnesium, pH, potassium, sodium and TON.	mg/l
		Annually	Hazardous Substances Suite	µg/l

2.8.4 Leachate is currently pumped from these wells to a holding tank. Leachate in the holding tank is emptied into a bowser, transferred by tractor and discharged into the treatment plant at the nearby Brookhill Landfill Site.

[10] 1240.3.FCC.JDM.AKS.A0 Leachate Management Plan; Caulmert Ltd. June 2011

Management Objectives

2.8.5 Monitoring and management of leachate will continue until it can be demonstrated that there is no discernible impact from the site in order to support a Permit surrender application.

3 MONITORING OF RESTORATION

3.1 Engineering Surveys

3.1.1 Annual topographic surveys will be completed at the site until Permit Surrender (unless otherwise agreed in writing by NRW).

3.1.2 Stable, permanent survey control stations shall be established and maintained for the control of all survey work around the Site. The stations shall be referenced to Ordnance Survey National Grid co-ordinates, the grid alignment to be within +/-1metre and levels referenced to Ordnance Datum.

3.1.3 The scale will adequately show surveyed features and be at least 1:1250. The surveys will be sufficient to produce plans that include all roads, structures, boundaries, monitoring points and all other relevant site features. The results of the survey shall be presented as a plan. Plan positions of ground features will be shown to within 1m. Spot levels to 0.01m shall be shown at significant landform changes to a density to adequately indicate the true landform, no greater than 50m intervals in open areas of even gradient, closer when indicating embankments, etc.

3.1.4 The results of the survey will be submitted to NRW by 31st January each year as part of the Annual Environmental Monitoring review.

3.2 Site Inspection

3.2.1 On a six monthly basis, the Site will be inspected by the operator to check the condition of any site infrastructure and whether there is any evidence of illegal tipping or vandalism and the general condition of the Site. Such findings of such inspections will be recorded in the Inspection Proforma located within Appendix C.

3.2.2 An additional inspection shall be carried out after any incident that may compromise the security of the Site. Damage to fencing and gates or perimeter barriers that are found to be in poor condition will be temporarily repaired as soon as practicable, and permanently repaired within two weeks of the inspection. A record of all inspections, damage and repairs will be maintained and details of inspections and any maintenance carried out will be forwarded to NRW.

3.3 Inspection of Restored Surface

3.3.1 At least once a year, the entire Site will be inspected by the operator to check the condition of the restored surface. The inspection will follow the Operators – Annual Closed Site Restored Surface Inspection Pro Forma presented in Appendix C. This will take the form of a visual (non-intrusive) inspection to check for evidence of potential damage or wear to the restoration soils as a result of for example desiccation/cracking, soil erosion, excessive differential settlement or accidental damage.

3.3.2 Details of inspections and any maintenance carried out will be forwarded to NRW.

3.4 Inspection of boreholes

3.4.1 Maintenance of borehole headworks, locks, signs / identification labels and dedicated sampling installations shall be the responsibility of the Operator. Leachate extraction wells will also be dipped to base once a year.

3.4.2 Any lost or damaged sampling equipment e.g. gas taps, dedicated sampling equipment etc. shall be repaired or replaced within reasonable timescales. Sufficient spares should be carried to allow maintenance to be undertaken during routine monitoring visits. Details of all maintenance will be recorded in the Closed Site Inspection Pro Formas.

3.4.3 At all times installations shall be clearly visible. Vegetation should be cut as necessary from around both flush and raised headworks.

3.4.4 An identified need for maintenance of a particular installation should not reasonably prevent routine sampling and monitoring data being obtained.

4 MAINTAINING AND SUBMITTING RECORDS

4.1 Security and Availability of Records

4.1.1 The Opperator will make and keep records of a number of activities that form part of the operation of the Site. These records are summarised below:

- damage to fences and gates;
- maintenance records;
- changes to infrastructure;
- survey of restored surface and cap integrity;
- surveys during post-closure phase.

5.1.2 The records detailed above will be kept at the Operators main office during the aftercare management period for the Site. Records shall be kept until the Permit is surrendered.

5 REPORTING OF SIGNIFICANT EFFECTS

5.1 Significant Effects

5.1.1 The definition of significant effects may be considered to be at concentrations where there is potential to cause pollution to the environment or the risk of significant harm. As such, compliance values have been defined solely for landfill gas, based on background environmental levels and/or the relevant regulatory standards.

5.1.2 All monitoring parameters will have some degree of natural variation, consequently a breach is only considered to occur after the compliance values have been exceeded on a minimum of three consecutive occasions.

5.2 Significant Environmental Effects from Groundwater Compliance Level Breaches

5.2.1 In the event that a level limit is breached the following action plan will be followed. Monitoring data is entered into a database to detect upward trends in concentration so that steps can be taken to prevent levels from rising above the compliance level thus preventing significant environmental effects.

5.2.2 NRW shall be informed of any breaches of compliance level by means of a Schedule 6 notification.

5.2.3 The laboratory shall be instructed to retest the retained sample. This re-test may be adequate in identifying the result as erroneous.

5.2.4 If the re-test confirms that limits have been breached, then the borehole will be re-sampled and this sample tested for the relevant determinant.

5.2.5 If the results of the second sample also exceed the compliance level concentration, then the borehole in which the exceedance has occurred will be re-sampled and analysed for the failing determinant on monthly basis for a further three months. It may also be that adjacent boreholes could be sampled for analysis as part of the investigation.

5.2.6 Data will be reviewed by use of statistical and graphical presentations to establish the presence of any underlying trends. Groundwater levels will be reviewed to establish flow direction in order to determine whether the site is the most likely cause of any change in groundwater quality.

5.2.7 If the laboratory results from the additional monitoring show no indication of decline over a six month period, and the indication is that the site is the most likely cause of the increase in levels, then the proposals for the implementation for mitigation measures shall be submitted to NRW.

5.3 Significant Environmental Effects from Landfill Gas

5.3.1 This action plan establishes the steps required to be taken in the event of two key events relating to the control and monitoring of landfill gas at Standard Landfill Site. These are:

- Failure of any part of the gas control system; and
- The breach of a compliance limit for methane (1%) or carbon dioxide (specific for each monitoring point) in any of the perimeter landfill gas monitoring points.

5.3.2 In the event that the results of the perimeter borehole monitoring indicate that landfill gas concentrations are above the compliance limits, appropriate measures will be undertaken, as detailed below.

5.3.3 Investigate whether the gas control system is fully functioning and repeat monitoring.

5.3.4 If breach is noted again in a repeat monitoring of the same borehole, then the gas field data will be reviewed and balancing reconfigured to target specific wells by increasing extraction of gas adjacent to the affected areas so as to minimise any lateral migration.

5.3.5 Monitoring frequency may be increased in the borehole or in adjacent boreholes to gather additional information to aid in the investigation.

5.3.6 If migration is persistently observed in a specific borehole the monitoring data will be reviewed along with the gas field data and appropriate changes implemented as required. If the borehole is in a sensitive area then consideration will be given to increasing monitoring to a weekly frequency in that borehole or area.

5.3.7 The surrounding area will be inspected for signs of gas or leachate escaping or vegetation die back.

5.3.8 Should all efforts to re-balance the gas field prove ineffective in controlling the migration, the gas wells in the area of the migration will be inspected in detail to establish their effectiveness and remediation works will then be carried out if required. If the wells are proved to be ineffective then infrastructure improvements such as drilling additional wells may be implemented.

5.3.9 Routine monthly gas monitoring will recommence once 4 weeks have elapsed where methane concentrations below the compliance level are re-established.

5.3.10 NRW shall be informed of any breaches in landfill gas compliance limits, by means of a Schedule 6, Part A notification.

5.3.11 No compliance limits are in place for internal landfill gas monitoring. However, the gas management plant will be operated to ensure high levels of environmental control exist within the site.

5.3.12 Elevated oxygen concentrations in landfill gas well could identify air ingress into the system caused by damage to a wellhead caused by settlement or vandalism, or failure of a manifold component. In the event of such damage being observed during inspections, immediate action would be taken to make temporary repairs using jubilee clips, rubber sealing caps, compression joints etc. until more permanent repairs could be effected following isolation of the wellhead or manifold. Upon completion of a temporary repair a permanent repair will be undertaken within one calendar of month.

5.3.13 Observations of ground conditions, damage to perimeter boreholes, and name of personnel carrying out the inspections will also be recorded.

5.3.14 Emissions of Landfill gas could result in odour complaints. All complaints will be recorded and investigated. A substantiated odour complaint is likely due to a failed preventative maintenance plan or an act of vandalism, however all complaints will be investigated to determine the source and the immediate mitigating response. An evaluation of the effectiveness of the techniques used will be carried out on completion of any remedial actions or if the complaints.

5.3.15 Emission limits apply to the landfill gas flare emissions and these will be monitored annually in accordance with current published Environment Agency guidance. In the event of any breaches of these limits specialist landfill gas combustion experts will advise and respond accordingly.

5.3.16 During the post closure aftercare period there may be insufficient gas to support continual combustion. In these circumstances, the results of the routine system monitoring, which will provide data on the gas flows and concentrations within the different parts of the site, will be used to determine the most appropriate operational regime both in respect of the suction applied to the wells and the operational sequence of a flare, with the objective of ensuring that extraction and flaring of gas is optimised. It may be necessary to consider the operation of the flare on a non-continuous basis in order to optimise gas collection and flaring and minimise atmospheric emissions.

5.3.17 Alternatively a smaller flare or other suitable gas control measures may be installed, subject to permission, to treat the small quantities of gas produced.

5.4 Significant Environmental Effects from Elevated Leachate Levels

5.4.1 In the event that the results of the monitoring indicate that leachate levels are above the limits specified in the Permit, appropriate measures will be undertaken, as detailed below.

- Ensure that all pumps are operating as expected. Any defects in the system should be reported and repair works actioned;
- Identify any potential blockages in the pipework;
- Increase off site tankering rates as required until compliance achieved;
- Increasing monitoring frequency until compliance level is achieved;
- NRW shall be informed by means of a schedule 6 notification.

5.5 Significant Environmental Effects from Other Scenarios

5.5.1 The following categories of potential hazard/accident have been identified as being relevant to the installation:

- Spillages & Leaks;
- Fire;
- Explosion;
- Flood;
- Major Breach of Installation Capping.

5.5.2 An assessment has been carried out to determine the likelihood of occurrence of the different accident scenarios, and the consequences of such an occurrence. For each of the accidents identified, a likelihood category has been assigned and an estimate of the likely consequences made.

Spillages & Leaks

5.5.3 In the event of spillage of polluting materials, immediate action will be taken to contain the spillage.

The spillage will be reported to the Site Manager, who will assess the situation and decide on the most appropriate course of action and deployment of resource. The action taken will depend upon the size of the spillage, the location in relation to sensitive receptors and the nature of the spilled material.

5.5.4 Action taken may include some or all of the following:

- If possible the leak will be stopped;
- If safe to do so, the cause of the spill or leak will be isolated;
- If the spillage is small, adsorbent materials are used immediately to prevent the spill spreading. The area will be cleared and all contaminated material will be sent to an appropriately licensed facility for disposal;
- If the spill is larger, inert materials such as soils, clay or sand could be used to make a containment bund and specialist help can be sought to assist in clean-up and NRW will be informed;;
- If a vehicle is found to be leaking, it will be moved to a position where the spillage can be contained i.e. hard surfaced area, if it is safe to do so.

Fire

5.5.5 Waste management installations can represent a potential fire risk for a number of reasons:

- Installation buildings may contain electrical appliances and other sources of ignition along with materials that would readily burn;

- Maintenance activities on plant and equipment can represent a potential fire risk if necessary precautions are not taken,
- Subsurface fires or hotspots have been known to occur at landfill installations.
- All employees will undergo training relevant to their role in fire prevention, use of fire extinguishers where relevant, and emergency procedures.

5.5.6 Firefighting equipment will be kept on site at the old weighbridge.

5.5.7 The landfill gas management system will be monitored in line with the schedule outlined in section and adjusted where necessary to ensure that air entering the sealed gas extraction system is minimised.

5.5.8 All employees and contractors will remain vigilant regarding the breakout of fire at the site, and the emergency procedure and action plan outlined below are followed if a fire is observed.

5.5.9 Monitoring for subsurface fires will be routinely carried out during the regular monitoring of the landfill gas management system.

Fire Action Plan

5.5.10 One permanent installation buildings will remain on site. The original weighbridge office and canteen are adjacent to the landfill gas utilisation plant compound. Fire exits will remain clearly signed and unobstructed.

5.5.11 In the event that a subsurface landfill hot spot or underground fire is suspected, the following possible courses of action will be considered in consultation with the NRW:

- Turning off gas extraction wells in the vicinity of the fire/hotspot;
- Ensuring all leachate extraction wells are sealed to prevent oxygen entering the installation; and
- Dosage of water or leachate via boreholes or wells constructed to the appropriate depth.

5.5.12 A fire log will be maintained, it will include the following details:

- A record of all incidents of fire including date, time, nature and cause of the fire; and details on the action taken to extinguish the fire, and any subsequent changes to operational and emergency procedures.

5.5.13 NRW will be advised of all incidents of fire/hotspot as soon as practicable.

Explosion

5.5.14 The main risk of explosion at the installation is associated with the operation of the landfill gas collection and extraction system. The gas system is designed to meet all relevant British Standards.

5.5.15 The plant will contain explosion prevention features and the cable and connection standards are to ATEX zone certified standards.

5.5.16 In the event of an explosion, the action taken by installation personnel will be the same as that taken in the event of fire.

Major Breach of Installation Capping

5.5.17 This has also been discussed above in Section 2, however In the event that stability or settlement problems are discovered, appropriate remedial action will be taken as detailed below:

Capping Breach

5.5.18 The capping will be inspected by a competent engineer to assess the need for any remedial action, and proposals will be submitted to NRW for agreement. Revisions will be made to capping design to provide additional resistance to slippage or damage and agreed with NRW.

Instability of Waste Mass

5.5.19 If there is visual evidence of movement within the waste mass, or evidence from the regular topographical surveys, an engineer will review the situation, and appropriate remedial action will be taken following discussion and in agreement with NRW.

5.5.20 The action taken will depend upon the severity of the movement, the timescales over which the unstable mass will remain unsupported and the consequences of possible failure. Action taken may include continuing assessment and situation monitored through regular visual inspections and topographical surveys.

Differential Settlement

5.5.21 Remedial action taken will depend upon the severity of the differential settlement and whether it has affected the integrity of the cap, and may include some or all of the following actions:

- Surcharging affected areas with additional restoration soils to produce a landform with appropriate falls;
- Localised removal of capping layers, surcharging with waste or soils, and replacement of cap under appropriate levels of CQA;
- Replacement of drainage channels to ensure continued integrity of surface water drainage; and
- Review of design to accommodate predicted differential settlement by locally strengthening cap, providing additional thickness of capping materials, or incorporating irregular edges and boundaries to compensate for predicted settlement differentials.

6 DECOMMISSIONING

6.1 Landfill Infrastructure

6.1.1 General site infrastructure has, for the most part been retained after completion of active landfilling operations. The employee canteen and weighbridge office will continue to be maintained as these facilities are now utilised for the recycling services. Landfill gas utilisation plant will be decommissioned soon after landfill gas quality and volume decrease to levels when it cannot be sustained.

6.1.2 Any flare and associated active gas extraction systems will be decommissioned after these cannot be sustained, or when risk assessment has identified that these do not need to continue. Leachate management systems will be decommissioned and dismantled after issue of a Certificate of Permit Completion, or when risk assessment has identified that these do not need to continue.

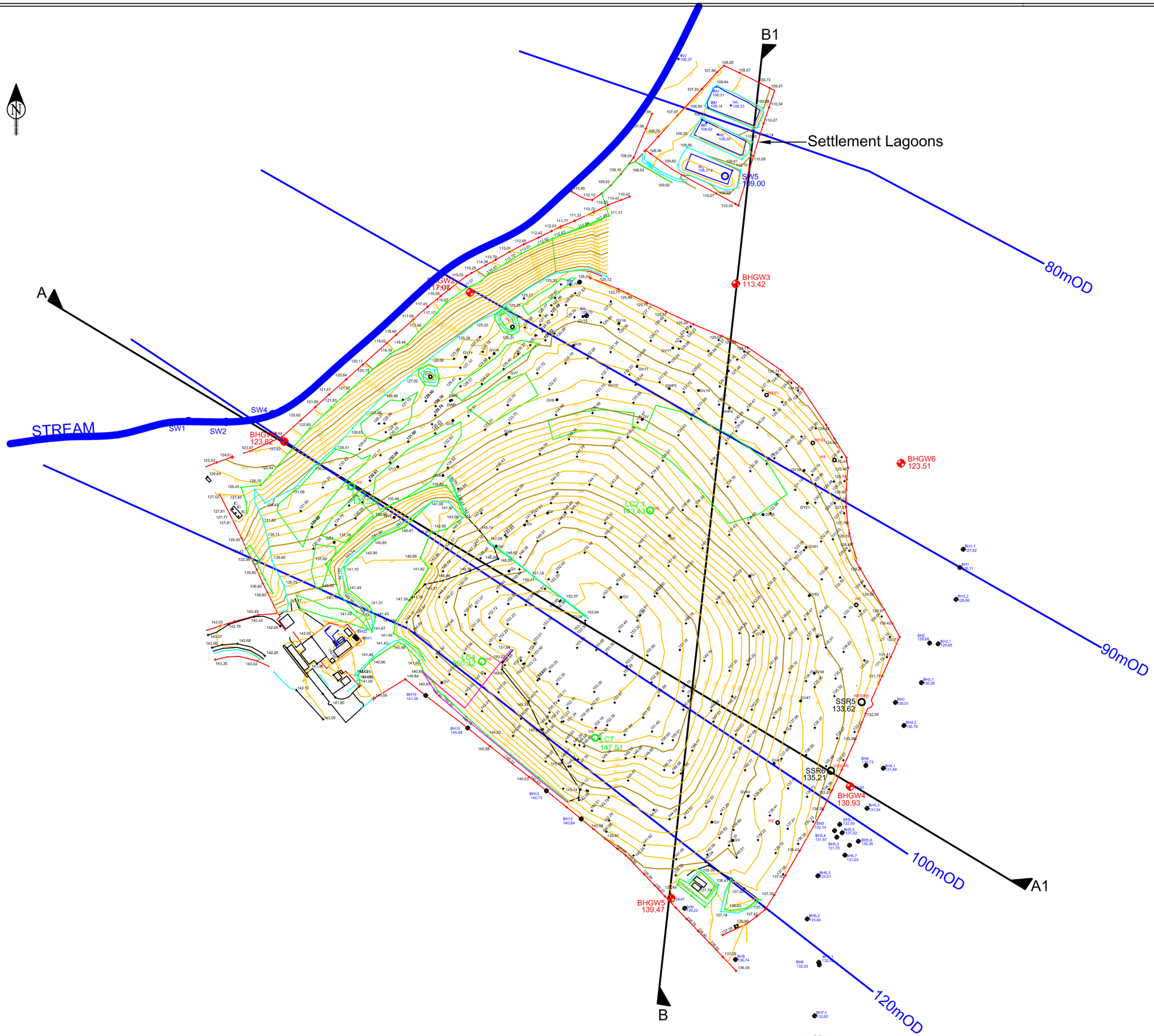
6.1.3 It is currently envisaged that all the components of the gas and leachate extraction systems below the landfill cap will be left in the waste. All headworks, pipework, manifold chambers etc. above the capping system will be removed as part of the decommissioning.

6.1.4 A method statement for the decommissioning of the landfill gas extraction system, the landfill gas utilisation plant, leachate extraction systems and any repair of penetrations through the landfill cap will be submitted to NRW for approval prior to the works being carried out.

6.1.5 Wells within the waste are subject to damage due to waste settlement and all infrastructures will have a finite operational life due to material decay or attack by external processes.

6.2 MRF Infrastructure

6.2.1 Most of the remaining site infrastructure relates to the household waste recycling centre that is regulated by a separate permit (BP3291EB), therefore decommissioning will be covered within the surrender of this Permit.



Notes

- BHGW4 — Groundwater Borehole
- SSR6 — Side Slope Riser
- LC7 — Leachate Chamber
- SW1 — Surface Water Monitoring Point
- Cross Section
- Ground Water Contours

Notes

Monitoring Point Height (mOD) Given Below Identity Number

Ground Water Contour Based on 2005 Levels

TerraConsult

Bold Business Centre, Bold Lane, Sutton, St Helens WA9 4TX

Client: A D Waste Limited

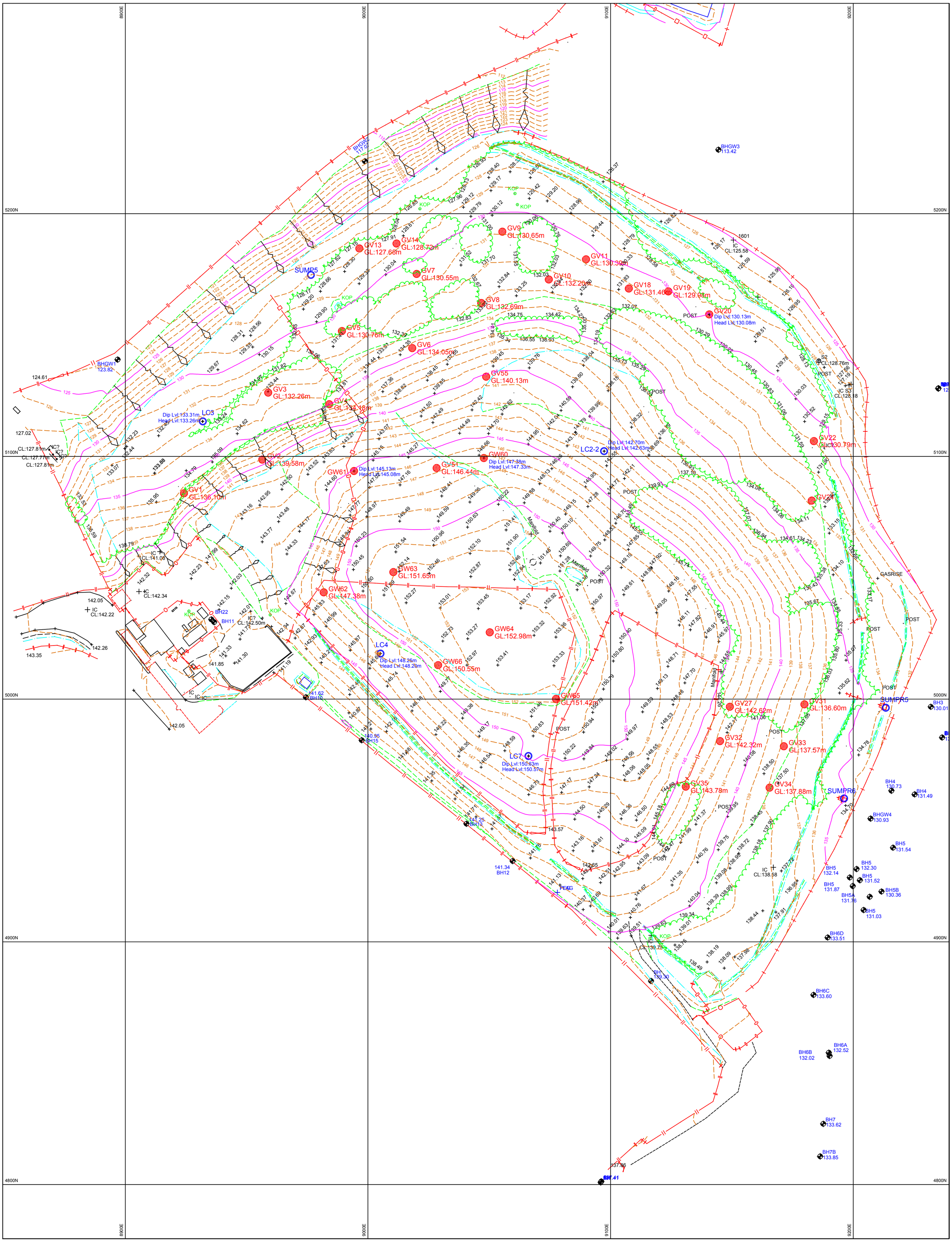
Site

Standard Landfill Buckley

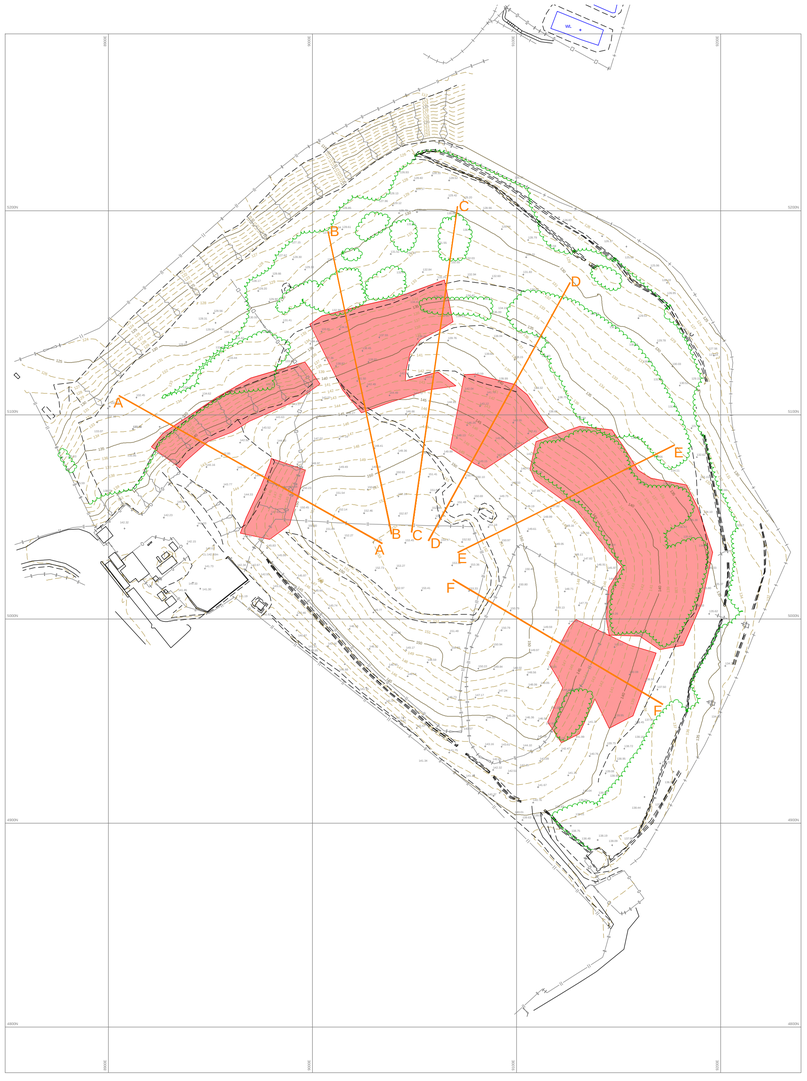
Title

Environmental Monitoring Locations

Scale	1:1500	@ A2	
Drawing No.	0987/1/002		
Rev	Date	Description	
File	Standard Landfill3863a-TCL Revision001.dwg		
Date	03/09	Engineer	CB
Drawn	SH	Checked	JB



Cyngor Sir y Fflint / Flintshire County Council (English / Cymraeg)	SITE: Standard Landfill	SCALE: 1:1000 @ A2	NOTES: Site Grid Shown; Levels Relate to Site Datum	stafsurv Land Surveyors
	PROJECT: Site Survey	DATE: 09/05/2017		www.stafsurv.com
		DRAWING No.: 9250a		Vernon Courtyard, Main Road, Sudbury, Derbyshire. DE6 5HS T 01283 584800 > F 01284 584844 > E info@stafsurv.com



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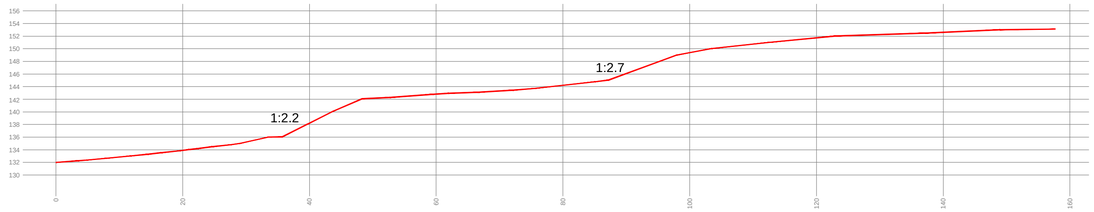
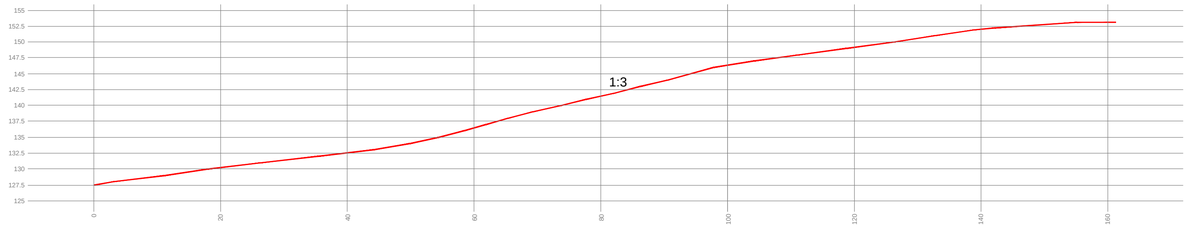


SECTION A-A (NTS)



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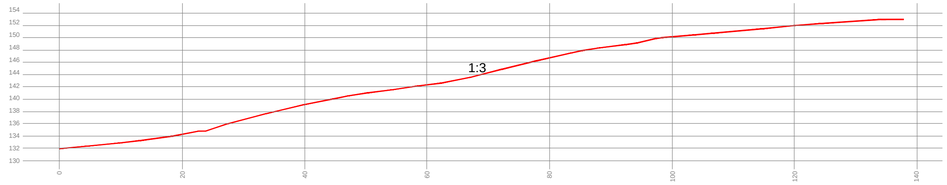

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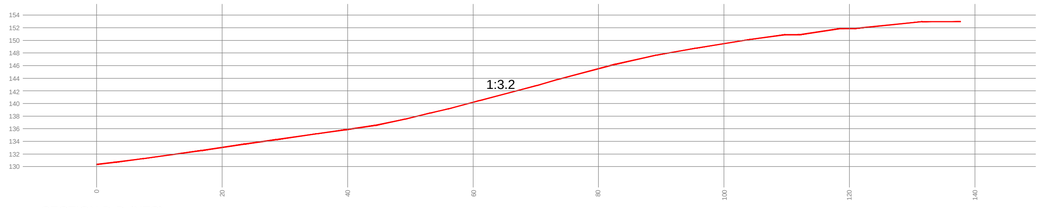

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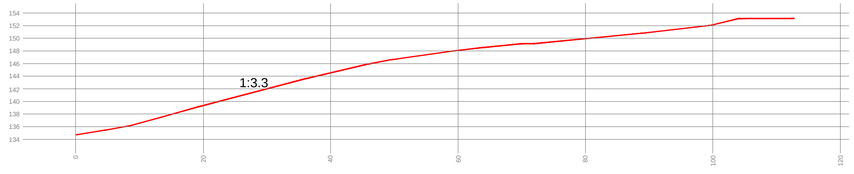
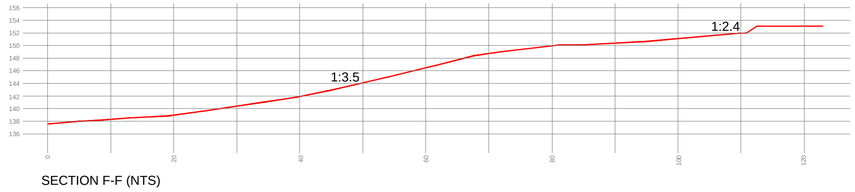


SECTION E-E (NTS)



SECTION F-F (NTS)

NOTE

1. DO NOT SCALE FROM THIS DRAWING, WORK FROM FIGURED DIMENSIONS ONLY. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM U.N.O.

2. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING WILL BE ALLOWED WITHOUT THE PRIOR PERMISSION IN WRITING.

3. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS, ENGINEERS AND SPECIALIST DRAWINGS AND SPECIFICATIONS.

4. BASED ON STAFF SURV DRAWING 9250a Standard 09-05-2017

REV	MODIFICATIONS	BY	RE	AP	DATE

Sir y Flint Flintshire COUNTY COUNCIL
English Cymraeg

PROJECT:

STANDARD CLOSURE PLAN

TITLE:

RESTORATION
SLOPE
PROFILES

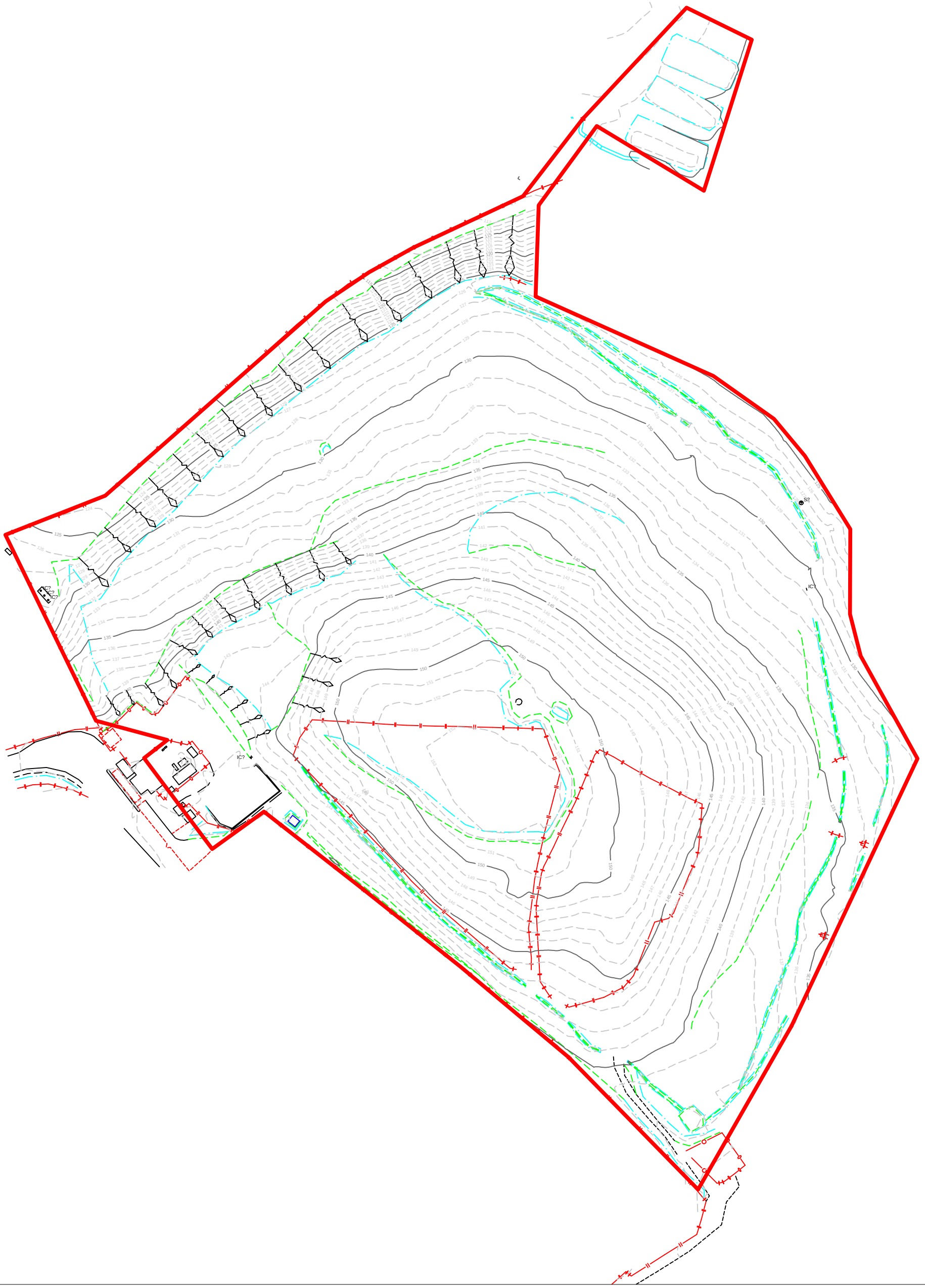
DRAWN BY	DATE	
EJD	01.11.2017	
REVIEWED BY	SCALE @ A1	JOB REF:
DO	AS SHOWN	3031
AUTHORISED BY	ISSUE	REVISION
-	A0	C1

DRAWING NUMBER

3031-CAU-XX-XX-DR-G-3800

Caulmert
engineering environmental planning

Registered Office: InTec, Parc Menai, Bangor, Gwynedd, LL57 4FG Company Registered No: 06716319



Flintshire County Council Waste Management Services	Standard Closure Plan	Area of Closure	Caulmert engineering environmental planning

JOB REF:	DRAWN BY	CHECKED BY	APPROVED BY	DATE	SCALE @ A3	DRAWING NUMBER	ISSUE	REVISION
3031	CF	SOB	SOB	01.12.2017	NTS	3031-CAU-XX-XX-DR-G-3801	-	-

Registered Office: InTec, Parc Menai, Bangor, Gwynedd, LL57 4FG Company Registered No: 06716319

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Appendix 1

Certificate No. CCC14656

Continuing Competence Certificate

This certificate confirms that

Andrew Scarfo

Has met the relevant requirements of the Continuing Competence scheme for the following award(s) which will remain current for two years from 09/06/2017

TSNH	Transfer - Non Hazardous Waste
TMNH	Treatment - Non Hazardous Waste

Awarded: 09/06/2017

Expiry Date: 09/06/2019

Authorised

WAMITAB Chief Executive Officer

CIWM Chief Executive Officer

The Chartered Institution of Wastes Management

00114447

Certificate No. CCC11953

Continuing Competence Certificate

This certificate confirms that

Paul Frederick Murphy

Has met the relevant requirements of the Continuing Competence scheme for the following award(s) which will remain current for two years from 03/03/2016

LNH	Landfill - Non Hazardous Waste
TSH	Transfer - Hazardous Waste
TMNH	Treatment - Non Hazardous Waste

Awarded: 03/03/2016

Expiry Date: 03/03/2018

Authorised

WAMITAB Chief Executive Officer

CIWM Chief Executive Officer

The Chartered Institution of Wastes Management

00103727

Certificate No. CCC13243

Continuing Competence Certificate

This certificate confirms that

Ruth Cartwright

Has met the relevant requirements of the Continuing Competence scheme for the following award(s) which will remain current for two years from 20/05/2016

LNH	Landfill - Non Hazardous Waste
TSH	Transfer - Hazardous Waste
TMNH	Treatment - Non Hazardous Waste

Awarded: 20/05/2016

Expiry Date: 20/05/2018

Authorised

WAMITAB Chief Executive Officer

CIWM Chief Executive Officer

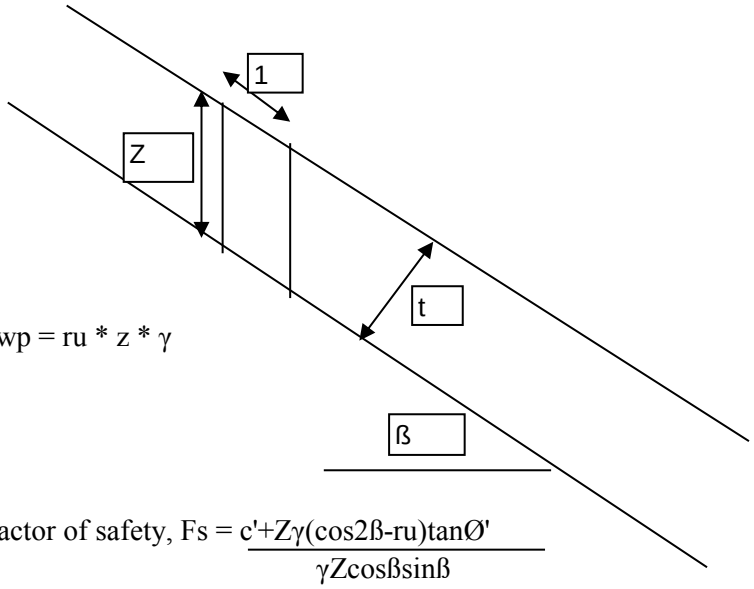
The Chartered Institution of Wastes Management

00106943

Appendix 2

Peak Strength

Subgrade or Protection Layer (Sand) / textured Geomembrane



pwp = ru * z * γ

Factor of safety, $Fs = \frac{c'+Z\gamma(\cos 2ß - ru)\tan Ø'}{\gamma Z \cos ß \sin ß}$

Data Input

t	1	m
ru	0	
γ	18	kN/m3
cot ß	2	
c'	7	kN/m2
Ø'	27	°

Calculations

ß	0.463648	rads =	26.6 °
Z	1.12	m	

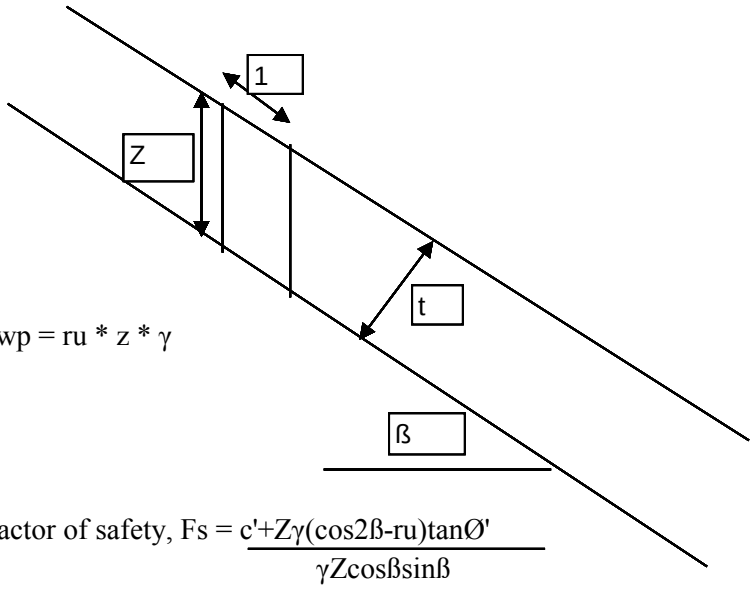
Fs = 1.89

ru	**Fs**
0.2	1.63
0.25	1.57

INFINITE SLOPE STABILITY

Peak Strength

Subgrade or Protection Layer (Sand) / textured Geomembrane



pwp = ru * z * γ

Factor of safety, $Fs = \frac{c'+Z\gamma(\cos 2ß - ru)\tan Ø'}{\gamma Z \cos ß \sin ß}$

Data Input

t	1	m
ru	0	
γ	18	kN/m3
cot ß	3	
c'	7	kN/m2
Ø'	27	°

Calculations

ß	0.321751	rads =	18.4 °
Z	1.05	m	

Fs = 2.76

ru	**Fs**
0.2	2.42
0.25	2.33

INFINITE SLOPE STABILITY

Appendix 3

Annual Closed Site Restored Surface Inspection Pro Forma

SITE: ..... **Date:**

Arrival Time:	
Departure Time:	
Inspection By:	
Weather:	
Progress of Restoration:	

Site Status

Desiccation/cracking:	
Soil erosion:	
Differential settlement of surface:	
Presence of objects which may obstruct cultivation/mowing:	
Area of willow/ash scrub encroachment:	
Area of vegetation stress/dieback:	
Vegetation description / height:	
Other Relevant Information:	

INSPECTED BY: ..... **DATE:** .....

Copy to Compliance Manager: ..... **DATE:** .....

Appendix 4

Caulmert Limited

Engineering, Environmental & Planning
Consultancy Services

Standard Landfill Site

Flintshire County Council Waste Management Services

Landfill Gas Management Plan

Prepared by:

Caulmert Limited
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Document Reference: 1240.4.FCC.JDM.ÅKS.A2

March 2012

APPROVAL RECORD

Site:	**Standard Landfill Site**
Client:	**Flintshire County Council Waste Management Services**
Document Title:	**Landfill Gas Management Plan**
Document Ref:	**1240.4.FCC.JDM.ÅKS**
Report Status:	**FINAL (A2)**
Project Director:	**Åsa Strickland**
Project Manager:	**Jim McClymont**
Caulmert Limited:	**Unit F13, Parc Menai, Bangor, Gwynedd, LL57 4FG**
Tel:	**01248 672666**

Author	Jim McClymont	**Date**	12.03.2012
Reviewer	Åsa Strickland	**Date**	12.03.2012
Approved	Åsa Strickland	**Date**	15.03.2012

DISCLAIMER

STANDARD LANDFILL SITE

LANDFILL GAS MANAGEMENT PLAN

TABLE OF CONTENTS

DRAWING

Drawing No.1240/SURV/01 – Standard Landfill Site Survey

APPENDICES

Appendix 1 Landfill Gas Monitoring Checklist
Appendix 2 Gas Extraction System Maintenance
Appendix 3 Carbon Dioxide Trigger Level Derivation
Appendix 4 Contact Details – Critical Plant

1.0 INTRODUCTION

1.1 Background

1.1.1 Flintshire County Council Waste Management Services (FCC) appointed Caulmert Limited (Caulmert) to revise and update the current Landfill Gas Management Plan for Standard Landfill Site to reflect current site conditions.

1.1.2 Standard Landfill Site is located approximately 1 km north-east of Buckley town centre, Flintshire, North Wales (NGR SJ 290 650). The site is accessed via the B5127 (Liverpool Road). The site is now closed and fully restored.

1.1.3 This document has been prepared in parallel with the Closure Plan in order to outline the management of landfill gas at the site in its post-closure period reflecting the decreasing source term. It includes a monitoring plan and an action plan with reference to Environment Agency Landfill Technical Guidance Note 03, 'Guidance on the management of landfill gas'[1].

[1] Environment Agency. 2004. LFTGN 03. Guidance on the management of landfill gas.

2.0 SITE DESCRIPTION (CONCEPTUAL MODEL)

2.1 Site History and Development

2.1.1 Standard Landfill Site was developed in the void created by a former open cast coal mine extending to approximately 13.3 ha. The site was excavated to a depth of approximately 100 mAOD (metres above Ordnance Datum), the site entrance being at 141 mAOD.

2.1.2 The site comprises six distinct cells. They were developed on the basis of containment of leachate by basal and side slope engineering with engineered clay, and subject to construction quality assurance.

2.1.3 Landfilling at the site commenced in January 1990 and continued until 2003. Planning Permission was granted in September 2000 to allow re-profiling of the upper surface of the site to improve surface drainage. The majority of the final landfilling activity was carried out using construction industry and inert type waste streams that are likely to yield low gas quantities.

2.1.4 Capping of the site was carried out using a 1.0 mm flexible membrane liner (FML) that was covered with clays and final restoration soils. The whole site area has now been restored and a Closure Plan is being prepared for submission to the Environment Agency.

2.2 Geology

2.2.1 The underlying geology of the site consists of a sequence of grey mudstone with sandstone bands, interbedded with coal. The coal bands are between 0.2 and 1.5 m thick, while the mudstone/sandstone bands can be up to 26 m thick in places, but are more commonly found with thicknesses in the order of 10 m.

2.2.2 Bands of pure mudstone are also present at the site, indicating a heterogeneous nature to the mudstone/sandstone lithology. Shales are also noted as occurring in conjunction with the coal bands. In a few instances, bands of black mudstone are found at depths greater than 100 mAOD.

2.3 Hydrogeology

2.3.1 Groundwater flow at the site is predominantly through silt and mud bands. There is also potential groundwater flows at the site through adducts and old workings, present in the underlying coal measures.

2.4 Hydrology

2.4.1 The site is enclosed by streams to the west and north. There are several large bodies of surface water at the site. There is a pond situated approximately 500m west of the site, in agricultural fields and there is also a large lake 500m south of the site.

2.5 Receptors

2.5.1 The site is bounded to the east by Burntwood Road where several residential properties have boundaries within 50 m of the eastern extreme of the site. To the west of the site lies agricultural land, separated from the landfill boundary by a water course.

2.5.2 Spencer Industrial Estate, which comprises several small industrial units, is situated beyond the southern site boundary. The A55 dual carriageway runs adjacent to the northern boundary.

2.6 Source Term

2.6.1 Approximately 1.4 million tonnes of waste were deposited during the site's operational lifespan. Waste input data (with waste type analysis) has previously been used to create gas production curves that estimated projected gas yields over time using GasSim modelling software.

2.6.2 The modelling concluded that the maximum predicted gas generation rate would occur between the years 2000 – 2005 and would be in the order of 1,400 m^3/h (as 50 %ile) and reduce thereafter.

3.0 LANDFILL GAS MANAGEMENT

3.1 Management Structure

3.1.1 The responsibilities for the delivery of the landfill gas management plan for Standard Landfill Site lie with the Energy and Compliance Manager, and the Environmental Management Coordinator.

3.1.2 The role of the Energy and Compliance Manger is to maintain contact with the relevant Environment Agency (EA) officer and to schedule the relevant site works and report production.

3.1.3 The role of the Environmental Management Coordinator is to schedule and conduct the site monitoring exercises, and report exceedances of site trigger levels to the relevant officer.

3.2 Landfill Gas Control System

3.2.1 An active gas control system has been installed at the site. This comprises a perimeter ring main with one 14 port manifold and two 8 port manifolds linked to purpose designed gas extraction wells via 63 mm diameter buried gas feeder lines. The remainder of the wells have direct connections to the perimeter main and are regulated for flow according to the results of gas balancing data gathered as part of routine gas field monitoring. The ring main feeds the gas to the Landfill Gas Utilisation Unit (section 3.3).

3.2.2 The site has a network of 54 160 mm diameter gas extraction wells installed at various spacing but typically not exceeding 40 m centres. Seven additional 125 mm diameter wells were installed in 2010.

3.2.3 A number of different wellhead designs are in use. All fulfil the same basic purpose to provide individual gas flow control at the well with provision to sample gas quality and check liquid levels within the well. Flexible couplings also allow for settlement movement to be accommodated as the waste settles. The wellheads are protected and secure within pre-cast concrete chamber rings with locked covers.

3.2.4 Individual wells are connected to the gas manifold using 63mm or 90mm SDR 17.6 pipework. Where required, a reducer is used at the connection with the manifold inlets. Two additional 8 port manifolds were installed in September 2007 to provide improved gas balancing capability and improve the collection efficiency by replacement of small bore gas feeder lines with larger diameter collector pipe.

3.2.5 Manifolds have multiple 63mm diameter in-line ports with Type 1003-05C ‘Safi’ valves (or similar) on each inlet. A butterfly (or similar) valve and further monitoring point is also fitted on the main exit line of the manifold.

3.2.6 The gas main is installed so to ensure a consistent fall along its length to the locations of the condensate de-watering facilities. Condensate dewatering pots have been installed at

strategic points along the gas main to intercept condensate that would otherwise restrict gas flow and cause problems at the power plant. Depending on the precise location of the dewatering facility and site conditions, condensate is typically drained directly back into the waste mass or pumped to a soakaway or other approved point using an automatically controlled pneumatic sub-mersible pump.

3.2.7 The pumped dewatering pots contain a short compressed air pump, usually AP3 (or equivalent) that is used to transfer collected condensate from the pot to the nearest designated disposal point on site. Compressed air necessary to operate the pump is supplied via 32mm MDPE SDR 11 pipework or similar, jointed using either welded or compression fit connections. The airline terminates at the dewatering pot with an isolation valve, pulse counter and pressure regulator with auto-drain.

3.2.8 The gas is directed to a landfill gas utilisation unit which is located to the north east of the site office as can be seen on drawing no.1240/SURV/01.

3.3 Technical Specification of Landfill Gas Utilisation Unit

3.3.1 The gas utilisation scheme includes an environmental compound that houses the electricity generating engine and a back up flare to be used in the event of the failure of the engine.

3.3.2 The electricity generating engine at the site is a Caterpillar G3516 which was installed by Finning (UK) Limited. It is designed to meet current emissions standards[2]. The engine was initially rated at 1025 kW, but is currently de-rated to approximately 650 kW.

3.3.3 Engine operation and management is undertaken by FCC. Failures of the engine are reported immediately to the Energy and Compliance Manger. Engine service and repair work is undertaken by Finning (UK) Limited on behalf of FCC.

3.3.4 A diaphragm valve controls the gas flow between the flare and the engine prioritising the engine. If the engine is out of service landfill gas is manually diverted to the flare in order for gas extraction to continue.

3.4 Future Management

3.4.1 As the waste mass ages, the gas resource is declining. As landfill gas generation rates within the site decline further, engine use will also decline and gas flaring will be used more often. Currently power export from the gas engine has been reduced to prevent over extraction of the gas field.

3.4.2 FCC have recently installed a new flare will be capable of a flow rate of 500 m^3/h, with a 10:1 turndown ratio. The new flare was installed in autumn 2011.

[2] Environment Agency. 2004. LFTGN 08. Guidance for monitoring landfill gas engine emissions.

3.4.3 Seven new extraction wells were installed in the south west area of the site, close to the landfill gas utilisation compound in September 2011. The new wells target landfill gas generation within waste at depth. It is hoped that the additional wells will increase the volume of gas being extracted from the site and perhaps prolong the viability of the engine.

3.4.4 The landfill gas management system is reviewed regularly, and the efficiency and adequacy of the landfill gas extraction system is being assessed regularly. The environmental impact of landfill gas is reviewed in the Annual Review (see 4.8.4). Based on the assessments, the gas extraction system will be updated as required.

4.0 LANDFILL GAS MONITORING PLAN

4.1 General

4.1.1 The purpose of the monitoring plan is to describe the monitoring methodology, frequencies and assessment levels of the landfill gas parameters which will be monitored routinely. In addition, the plan provides contingency plans for dealing with impacts arising from the generation of landfill gas.

4.1.2 Landfill gas monitoring is carried out at all perimeter boreholes. All emissions suites and trigger levels for these monitoring points are outlined in this plan. In the event of a breach of the trigger levels the Environment Agency must be informed of both the breach and any intended remedial action, and the Landfill Gas Emergency Action Plan contained in Section 5 will be implemented if required.

4.1.3 In-waste gas monitoring boreholes are monitored monthly. Trace gas analysis at the input to flare is currently undertaken annually. Fugitive emissions of landfill gas, flare emissions and engine emissions are also monitored annually. All emission suites for these monitoring points are outlined in this plan.

4.1.4 In the event of a failure in the gas utilisation compound or gas extraction installations the landfill gas Emergency Action Plan contained in Section 5 will be implemented.

4.1.5 All records of any maintenance or repairs to the gas extraction system are logged in a log book. The fault, repair/replacement and person/s carrying out the works are recorded. It includes any routine repairs or replacements the gas extraction system requires. The records are stored by the operator on site and made available for inspection on demand.

4.2 Perimeter Gas Monitoring System

Monitoring Regime

4.2.1 Lateral emissions monitoring is carried out on 26 perimeter boreholes. These perimeter monitoring boreholes will be monitored monthly for the presence and concentrations of bulk landfill gases methane (CH_4) and carbon dioxide (CO_2). Monitoring borehole locations are shown on drawing number 1240/SURV/01 in Appendix 1.

4.2.2 A suggested monitoring protocol and checklist for landfill gas monitoring can be found in Appendix 2.

4.2.3 The perimeter monitoring regime is summarised in Table 1 and the relevant trigger levels in Table 2 & 3 below. Trigger levels for carbon dioxide in perimeter boreholes have been derived using statistical analysis of background concentrations. Details regarding their derivation can be found in Appendix 3.

Table 1: Perimeter Landfill Gas Sampling Regime

Test type and monitoring points	Total	Frequency	Parameters	Unit
BH1, BH1.1, BH2.0, BH2.1, BH2.2, BH3.0, BH3.1, BH4.0, BH4.1, BH4.2, BH5.0, BH5.1, BH5.2, BH5.3, MBH5.4, MBH5.5, MBH5.7, BH6.3, BH7.0, BH7.1, BH9.0, BH12, BH13, BH15, BH16, BH22	26	Monthly	CH_4, CO_2, O_2 CO, H_2S Atmospheric pressure* Relative pressure	% v/v ppm mb mb

* The pressure tendency (rising or falling) should be recorded during gas monitoring occasions

Table 2: Perimeter Landfill CH_4 Gas Trigger Levels

Trigger Level Action Plan			
Gas	**Monitoring point**	**Trigger level (%)**	**Action**
Site Perimeter			
CH_4	BH1, BH1.1, BH2.0, BH2.1, BH2.2, BH3.0, BH3.1, BH4.0, BH4.1, BH4.2, BH5.1, BH5.2, BH5.3, MBH5.4, MBH5.5, MBH5.7, BH6.3, BH7.0, BH7.1, BH9.0, BH15,	1.0 5.0 8.0	**Breach of trigger level** Inform site manager/supervisor; Inform the Environment Agency and the Environmental Health Department at Flintshire County Council of both the breach and of any intended remedial action; Follow steps outlined in Section B1 of the Emergency Gas Action Plan (Section 5).
	BH12, BH13, BH16 BH5 BH22	10.0 15.0 40.0*	**Breach of trigger level** Follow steps outlined in Section B1 of the Emergency Gas Action Plan (Section 5).

***to be re-assessed when monitoring data is available.**

Table 3: Perimeter Landfill CO_2 Gas Trigger Levels

Trigger Level Action Plan			
Gas	**Monitoring point**	**Trigger level (%)**	**Action**
Site Perimeter			
CO_2	BH 1	5.4	**Breach of trigger level** Inform site manager/supervisor; Begin daily monitoring of affected borehole; If breach for more than 5 days follow steps outlined in Section B2 the Emergency Gas Action Plan (Section 5).
	BH 1.1	5.4	
	BH 2.0	7.0	
	BH 2.1	7.6	
	BH 2.2	5.8	
	BH 3.0	6.7	
	BH 3.1	7.8	
	BH 4.0	10.6	
	BH 4.1	7.1	
	BH 4.2	8.6	
	BH 5.0	19.4	
	BH 5.1	5.8	
	BH 5.2	9.6	
	BH 5.3	6.0	
	STMBH 5.4	16.0	
	STMBH 5.5	17.1	
	STMBH 5.7	7.1	
	STBH 6.3	8.2	
	STBH 7.0	6.2	
	STBH 7.1	5.5	
	STBH 9.0	10.7	
	STBH 12	6.5	
	STBH 13	5.2	
	STBH 15	8.3	
	STBH 16	1.5*	
	STBH 22	1.5*	

***to be re-assessed when further monitoring data is available.**

Maintenance of Landfill Gas Extraction and Monitoring System

4.2.4 Maintenance of borehole headworks, locks, signs/identification labels and dedicated sampling installations shall be the responsibility of FCC.

4.2.5 Any lost or damaged sampling equipment e.g. gas taps etc, shall be repaired or replaced by FCC immediately. Sufficient spares should be carried to allow maintenance/replacement to be undertaken during routine monitoring visits.

4.2.6 Landfill gas engine, flare and leachate pumps are subject to routine maintenance schedule. All service records are kept and archived in the site office. A monitoring checklist which details maintenance schedules for the gas field and the gas plant is included in Appendix 2.

4.2.7 Any damage to the landfill gas collection system is noticed in the daily site walk-over. Immediate action to repair damage will be taken. The site carry a stock of spare fittings of various diameters, and two staff are certified to carry out repairs using butt fusion and electro-fusion methods.

4.2.8 The Energy and Compliance Manager is responsible for checking the maintenance log book and confirming that repairs are completed. The log book shall be checked at least weekly.

4.2.9 At all times installations shall be clearly visible and clearly identified on the ground. Vegetation should be cut as necessary from around both flush and raised headworks.

4.2.10 An identified need for maintenance of a particular installation should not reasonably prevent routine sampling and monitoring data being obtained.

Sampling Equipment and Methods

4.2.11 Gas readings will be taken using a portable infra-red Gas Analyser (GA). Geotechnical Instruments GA2000 has in-built logging facility, which is suitable for the measurement of landfill gas % level of bulk gases, certain trace gases as well as the barometric pressure, relative pressure. The instrument should be serviced and calibrated in-line with the manufacturer's recommendations. All instrument service and calibration dates will be provided should the Environment Agency so request.

4.2.12 The monitoring staff have received relevant training and experience to undertake landfill gas monitoring. Details of their training and experience are kept on site and will provide evidence of their suitability for the task. These details will be updated when necessary.

4.2.13 All sampling procedures will be in line with the recommendations of LFTGN 03. A monitoring schedule is included in Appendix 1 of this plan.

4.2.14 All maintenance of equipment is to be recorded and logged in a log book. Records are to be kept on site by the operator and made available for inspection on demand.

4.3 In-waste Gas Monitoring System

General

4.3.1 In-waste boreholes will be monitored regularly in order to provide information about the gas field and to assist the balancing of the gas extraction system.

Monitoring Regime – gas extraction wells

4.3.2 The gas extraction wells will be used as monitoring points to determine in-waste gas concentrations (CH_4, CO_2, O_2 etc) on a monthly basis. Carbon monoxide, meteorological conditions and relative pressure details will also be monitored on a monthly basis. Details of the monitoring schedule are given in Table 4 below:

Table 4: Gas Collection System Monitoring

Test type and monitoring points	Frequency	Parameters	Unit	Other Specifications
All installed gas extraction wells	Monthly	CH_4, CO_2, O_2 CO H_2S Relative Pressure	% v/v ppm ppm mb	Where the O_2 level exceeds 5% or where the addition of CO_2 and CH_4 percentages is less than 80% the extraction from the gas well shall be reduced and an assessment of air ingress into the system shall be undertaken. Where the concentration of CO exceeds 100ppm then further investigation shall be undertaken.
Input to gas plant	Annually	Trace Gas Analysis	-	-

* Monitored continuously by the on-site weather station

Sampling Equipment & Methods

4.3.3 A real-time landfill gas analyser GA2000 (or similar) will be used in monitoring of landfill gas concentrations in gas wells and manifolds. All equipment (in-house or third party) should be serviced and calibrated in-line with the manufacturer's recommendations. All instrument service and calibration dates will be provided should the Environment Agency so request.

4.3.4 All sampling procedures will be in line with the recommendations of LFTGN 03.

4.3.5 Records of all maintenance of equipment are to be logged in a log book. Records are to be kept on site by the operator and made available for inspection on demand.

4.3.6 Sampling and analysis of trace gas composition at the input to the gas plant be carried out annually (at the same time as gas plant emission monitoring, Section 4.4) in accordance with the Environment Agency technical document LFTGN 04[3] Guidance for Monitoring Trace Components in Landfill Gas.

4.3.7 The proposed the trace gas sampling and analytical methods are summarised in Table 5 below:

[3] Environment Agency. Sept 2004. LFTGN 04. Guidance for Monitoring Trace Components in Landfill Gas.

Table 5: Trace Gas Sampling and Analytical Methods

Trace gas compounds	Sampling method	Analytical method
1,1-Dichloroethane	Dual solid sorbent	ATD-GC-MS
1,1-Dichloroethylene	Dual solid sorbent	ATD-GC-MS
1,2-Dichloroethylene	Dual solid sorbent	ATD-GC-MS
1,3-Butadiene	Dual solid sorbent	ATD-GC-MS
1-Butanethiol	Dual solid sorbent	ATD-GC-MS
1-Pentene	Dual solid sorbent	ATD-GC-MS
1-Propanethiol	Dual solid sorbent	ATD-GC-MS
2-butoxyethanol	Dual solid sorbent	ATD-GC-MS
Arsenic (as As)	Dual solid sorbent	ICP-MS/AAS
Benzene	Dual solid sorbent	ATD-GC-MS
Butyric acid	Dual solid sorbent	ATD-GC-MS
Carbon disulphide	Dual solid sorbent	ATD-GC-MS
Carbon monoxide	Gresham tube/Tedlar bag	Laboratory GC
Chloroethane	Dual solid sorbent	ATD-GC-MS
Chloroethene (vinyl chloride)	Dual solid sorbent	ATD-GC-MS
Dimethyl disulphide	Dual solid sorbent	ATD-GC-MS
Dimethyl sulphide	Dual solid sorbent	ATD-GC-MS
Ethanal (acetaldehyde)	Reactive sorbent	HPLC
Ethanethiol	Dual solid sorbent	ATD-GC-MS
Ethyl butyrate	Dual solid sorbent	ATD-GC-MS
Furan (1,4 epoxy 1,3-butadiene)	Dual solid sorbent	ATD-GC-MS
Hydrogen sulphide	Dual solid sorbent	ATD-GC-MS
Methanal (formaldehyde)	Reactive sorbent	HPLC
Methanethiol	Dual solid sorbent	ATD-GC-MS
Tetrachloromethane	Dual solid sorbent	ATD-GC-MS
Trichloroethene	Dual solid sorbent	ATD-GC-MS

4.3.8 The sampling train for collecting trace gas samples will comprise a low-flow pump and sampling tubes. Sampling will be conducted with parallel tubes (for QA) set at the same flow rates, regulated by the in-line flow rate calibrators.

4.3.9 All samples will be analysed by an UKAS accredited environmental laboratory.

4.3.10 An infra-red gas analyser GA2000 (or similar) will be used to monitor the presence and concentrations bulk gases CH_4 and CO_2 as well as trace gases H_2S and CO at the sampling point.

4.4 Monitoring of Combustion System Emissions

Monitoring Regime

4.4.1 The monitoring of the gas plant emissions to air is designed in accordance with Environment Agency Technical Guidance Note LFTGN 08[2]. The landfill engine will be monitored for the presence and concentrations of nitrogen oxides, carbon monoxide, total volatile organic compounds (VOC's) and total non-methane volatile organic compounds (NMVOC's).

4.4.2 The engine will be monitored for the presence and concentrations of the parameters, listed in Table 6 below:

Table 6: Engine Emissions Sampling Protocol

Parameter	Monitoring frequency	Emissions limits, mg/m^3	Monitoring method
		Engine	
Oxides of Nitrogen (as NO_2)	Annually	650	Extractive sampling & Chemiluminesence (ISO 10849:1996)
Carbon Monoxide (CO)	Annually	1500	Extractive sampling & Non-dispersive Infra-Red Analysis (ISO 12039:2002)
Total Volatile Organic Compounds (VOCs)	Annually	1750	Extractive sampling and FID analysis (BS EN 12619:1999, BS EN 13526:2002)
Total Non-Methane Volatile Organic Compounds (NMVOCs)	Annually	150	Extractive sampling onto sorbent, thermal desorption, analysis by GC (BS EN 13649:2002)

4.4.3 At present the use of the backup flare is limited to short periods of time – typically less than 10% of available hours annually. For this reason FCC do not currently undertake routine flare monitoring.

4.4.4 When gas utilisation is no longer feasible, during the latter stages of gas production, gas collected via the gas extraction field will be combusted using the landfill gas flare. This new flare is a replacement for the former backup flare.

4.4.5 If the flare is operational for more than 10% of time, flare monitoring will be undertaken on an annual basis in accordance with the requirements of Environment Agency Technical Guidance Note LFTGN 05[4], as detailed below.

4.4.6 The flare will be monitored for the presence and concentrations of the parameters, listed in Table 7 below:

Table 7: Flare Emissions Sampling Protocol

Parameter	Monitoring frequency	Emissions limits, mg/m^3	Monitoring method
		Flare	
Oxides of Nitrogen (as NO_2)	Annually	150	Extractive sampling & Chemiluminesence (ISO 10849:1996)
Carbon Monoxide (CO)	Annually	50	Extractive sampling & Non-dispersive Infra-Red Analysis (ISO 12039:2002)
Total Volatile Organic Compounds (VOCs)	Annually	10	Extractive sampling and FID analysis (BS EN 12619:1999, BS EN 13526:2002)
Total Non-Methane Volatile Organic Compounds (NMVOCs)	Annually	5	Extractive sampling onto sorbent, thermal desorption, analysis by GC (BS EN 13649:2002)

[4] Environment Agency. Sept 2004. LFTGN 05. Guidance for monitoring enclosed landfill gas flares.

Reporting of Results – Combustion Emissions

4.4.7 All test reports will contain details of the test methods, any variations from standard methods, tabulated data summary and ambient conditions during sampling. The results will be presented to include measurement uncertainty. This allowance of uncertainty will be used in reporting compliance or non-compliance emissions to the Environment Agency (refer to Section 9.5.1 LFTGN 05 and Section 5.6.1 LFTGN 08).

Quality Assurance

4.4.8 The selected contractor company will be endorsed by the Source Testing Association (STA) for particulate and gaseous sampling and have MCERTS accreditation covering source testing. A two man sampling team will be utilised for this work to comply with the company Health and Safety Policy. No monitoring work will be undertaken in close proximity to the top of the flare stack due to the unacceptable risks associated with potential exposure to high temperatures from wind whipping of the flare. All analysis would be undertaken by a UKAS and GLP accredited contract laboratory.

4.5 Fugitive Aerial Emissions

4.5.1 The operator shall take all appropriate measures possible to prevent and /or reduce fugitive emissions from the site. In particular from:

- filled landfill surfaces;
- storage areas;
- buildings;
- pipes, valves and other transfer systems.

4.6 Surface Emissions

4.6.1 In order to assess the adequacy of the capping in terms of gas permeability, surface emission monitoring will be undertaken using FID walk-over surveys and flux box monitoring. Details of the monitoring schedule are given in Table 8 below:

Table 8: Summary of Surface Emission Monitoring

Test type and monitoring points	Frequency	Determinant	Unit
FID walk-over survey	Annually	Methane emission rate	mg/m^2/second
The number and spacing of monitoring points is a function of the zone area and will be calculated as per LFTGN 07	Annually or every four years, see 4.6.4	Methane emission rate	mg/m^2/second

4.6.2 The monitoring will be carried out in accordance with the current Environment Agency's technical guidance document LFTGN07[5]. The methodologies of the walk-over survey and the surface emissions monitoring, the selection of the monitoring equipment, the locations and the number of sampling locations and the data assessment will be in accordance with LFTGN07.

4.6.3 A Flame Ionising Detector (FID) will be used during both the walk-over survey and the emissions monitoring. FIDs measure concentration of flammable gases, such as volatile hydrocarbons, inorganics etc. Within the context of landfill monitoring, FIDs are calibrated to methane (CH_4) and have a detection limit of 1 ppm CH_4.

4.6.4 The monitoring regime will incorporate the recommendations of the LFTGN 07: 'Permanently capped, closed areas progressively achieve a reliable degree of gas control. If you have previously shown a permanently capped zone to be compliant and there have been no significant physical changes in the gas management during the year, you can use an annual detailed walkover survey to demonstrate the surface emissions are under control. If these surveys show no change in the pattern of methane emissions, report the values for flux and total methane emissions measured from the previous compliant survey. If the zone remains stable, we will accept the results of full walkover surveys as the site report and not require a further quantitative flux box survey of the stable permanently capped zones'.

[5] Environment Agency. Sept 2004. LFTGN 07. Guidance on monitoring landfill gas surface emissions.

4.7 Summary of Landfill Gas Monitoring Requirements

4.7.1 Table 9 below summarises the landfill gas monitoring requirements at Standard Landfill Site:

Table 9: Summary of landfill gas monitoring requirements

Monitoring Location	Parameters	Frequency
Perimeter Boreholes	Methane	Monthly
	Carbon Dioxide	
	Oxygen	
	Carbon Monoxide	
	Atmospheric Pressure	
	Relative Pressure	
Gas extraction wells	Methane	Monthly
	Carbon Dioxide	
	Oxygen	
	Carbon Monoxide	
	Relative Pressure	
Input to gas plant	Trace Gas Analysis	Annually
Landfill Gas Engine Emissions	Oxides of Nitrogen (as NO2)	Annually
	Carbon Monoxide	
	Total Volatile Organic Compounds	
	Total Non-Methane Volatile Organic Compounds	
Landfill Gas Flare Emissions	Oxides of Nitrogen (as NO2)	Annually
	Carbon Monoxide	
	Total Volatile Organic Compounds	
	Total Non-Methane Volatile Organic Compounds	
Landfill Cap	FID Walk-over Survey	Annually
	Flux Box Survey	Annually or every 4 years

4.8 Records

4.8.1 All records made as a requirement of this Landfill Gas Monitoring Plan and any records made in relation to the permitted installation at Standard Landfill Site must be made available for inspection by the Environment Agency.

4.8.2 Records must be maintained of all the monitoring taken or carried out. This includes records of the taking and analysis of samples instrument measurements, calibrations, examinations, tests and surveys, and any assessment or evaluation made on the basis of such data.

4.8.3 Records supplied to the Environment Agency must:

- be legible;
- be made as soon as reasonably practicable;
- if amended, be amended in such a way that the original and any subsequent amendments remain legible, or are capable of retrieval;
  and;
- be retained, unless otherwise agreed in writing by the Agency, for at least 6 years from the date when records were made, or in the case of the following records until permit surrender;
  (i) sub-surface landfill gas monitoring;
  (ii) landfill gas generation and collection.

4.8.4 Any records required shall be supplied to the Agency within 14 days where the records have been requested in writing by the Agency.

4.8.5 All records shall be held on site and shall be available for inspection by the Agency at any reasonable time.

4.9 Data Handling & Reporting

4.9.1 The following compliance monitoring data will be reported from Standard Landfill.

4.9.2 Monitoring data shall include:

- Specified details such as date, time, location, personnel undertaking monitoring and equipment used;
- Weather conditions incl. barometric pressure;
- Determinants monitored;
- Results of measurements (with error limits);
- Interpretation and review of results; and
- Validation of accuracy and validity of results.

4.9.3 All monitoring results recorded will be reported to the Environment Agency within 28 days of the end of the reporting period.

4.9.4 *Annual review* - A review of the landfill site and all monitoring data will be included in the annual environmental report for the site. This will include analysis of the data to highlight any trends, and details of any proposed remedial actions in the event of any adverse trends or data. It will also include a *landfill gas management system review* (as detailed in section 3.4) and a *fugitive emissions review* (section 4.5). It shall be submitted no later than 31st January of the following year, unless otherwise agreed with the Environment Agency.

4.9.5 *Quarterly review* **-** A review of monitoring results for landfill gas and trigger levels will be produced on a 3 month basis. A summary report detailing this review will be sent to the Environment Agency within 1 month of the end of each 3 month period, i.e. January – March by 30th of April, April – June by the 31st of July, July – September by the 31st of October and October – December by the 31st of January of the following year.

4.9.6 *Technical Assessment* - The Environment Agency may request of the operator a report assessing whether all appropriate measures continue to be taken against pollution at the site. The report will consider any relevant published technical guidance current at the time of notice. It will assess the cost and benefits of applying such techniques suggested in the guidance that may provide environmental improvement. The report must be submitted within 6 months of receipt of the written notice.

4.9.7 This *Landfill Gas Management Plan* will be subject to review on an annual basis.

5.0 GAS ACTION PLAN

5.1 General

5.1.1 This action plan establishes the steps required to be taken in the event of two key events relating to the control and monitoring of landfill gas at Standard Landfill Site. These are:

a) failure in any part of the gas extraction system; and
b) the breach of a trigger level for methane or carbon dioxide in any of the landfill gas monitoring points at the site.

5.2 Failure of Gas Extraction System

5.2.1 Any future systems installed shall be inspected daily to ensure their continued function and the results of each inspection recorded in the site records.

5.2.2 A failure of any part of any future extraction system will trigger the implementation of section **A** of the action plan.

5.3 Trigger Level Exceedance

5.3.1 Landfill gas is monitored at 26 boreholes located around the perimeter of the site.

5.3.2 The current trigger levels for the site are outlined in Tables 2 and 3.

5.3.3 An exceedance in any of these will result in the implementation of section **B** of the action plan.

5.4 Plan Triggers

5.4.1 The triggers for the implementation of this plan are shown in Table 10.

Table 10: Action Plan

Incident	Action
Failure of Gas Extraction System	Instigate section **A** of action plan
Trigger level breached: Methane at any monitoring point	 Instigate section **B.1** of action plan
Carbon dioxide for 5 consecutive days at any monitoring point	Instigate section **B.2** of action plan

5.4.2 The following sections are a list of instructions to be followed upon the occurrence of any of the specified events. Unless otherwise stated the instructions are directed to the site manager or other designated competent authority.

****

A FAILURE OF GAS EXTRACTION SYSTEM

A.1 Identify cause of failure. Failures of the gas engine are reported immediately to the Energy and Compliance Manager.

A.2 Immediately start investigating the reason for the failure. Carry out review of gas extraction system and instigate immediate measures to remediate any problems identified.

A.3 If electric supply has failed, contact emergency electrician or if mains electricity supply has failed contact (electrical contractor).

A.4 If flare unit has broken down contact the equipment suppliers, or the nominated service engineer (Finning (UK) Ltd).

A.5 If the condensate pumping system has failed, contact the nominated service engineer.

A.6 Energy and Compliance Manager to inform the Environment Agency within 24 hours of the failure.

A.7 If it is deemed likely that the system will not be operational within 24 hours then make arrangements for alternative hire/replacement equipment to be provided as soon as possible.

A.8 A list of contact details for critical plant breakdown response is included in Appendix 4.

A.9 If elevated levels of methane are identified in the perimeter boreholes then section **B** of this action plan should be instigated.

B TRIGGER LEVEL BREACH

B.1 Methane trigger level breach at any monitoring point

B.1.1 Monitoring technician to inform Energy and Compliance Manager immediately and monitor in-borehole gas pressure.

B.1.2 Energy and Compliance Manager to inform the EA and forward results by email.

B.1.3 Energy and Compliance Manager to immediately start investigating the reason and nature of the breach. Carry out review of gas control system and instigate immediate measures to remediate any problems identified. If gas control system has failed instigate section **A** of action plan.

B.1.4 Whilst investigation is underway, the following measures will be implemented to reduce the methane and carbon dioxide to within the trigger levels.

1. The borehole will be passive vented in order to relieve any gas pressure.
2. The borehole shall then be monitored twice daily until the gas is below the agreed trigger level. All results will be forwarded to the EA.
3. Wells associated with the active gas extraction system will be monitored for gas quality.
4. If monitoring of the gas extraction system shows that excessive amounts of oxygen are being drawn into the system, oxygen ingress will be reduced through adjustment of individual wells or parts of the system.
5. Increased suction will be applied where possible to wells in the vicinity of the affected boreholes.

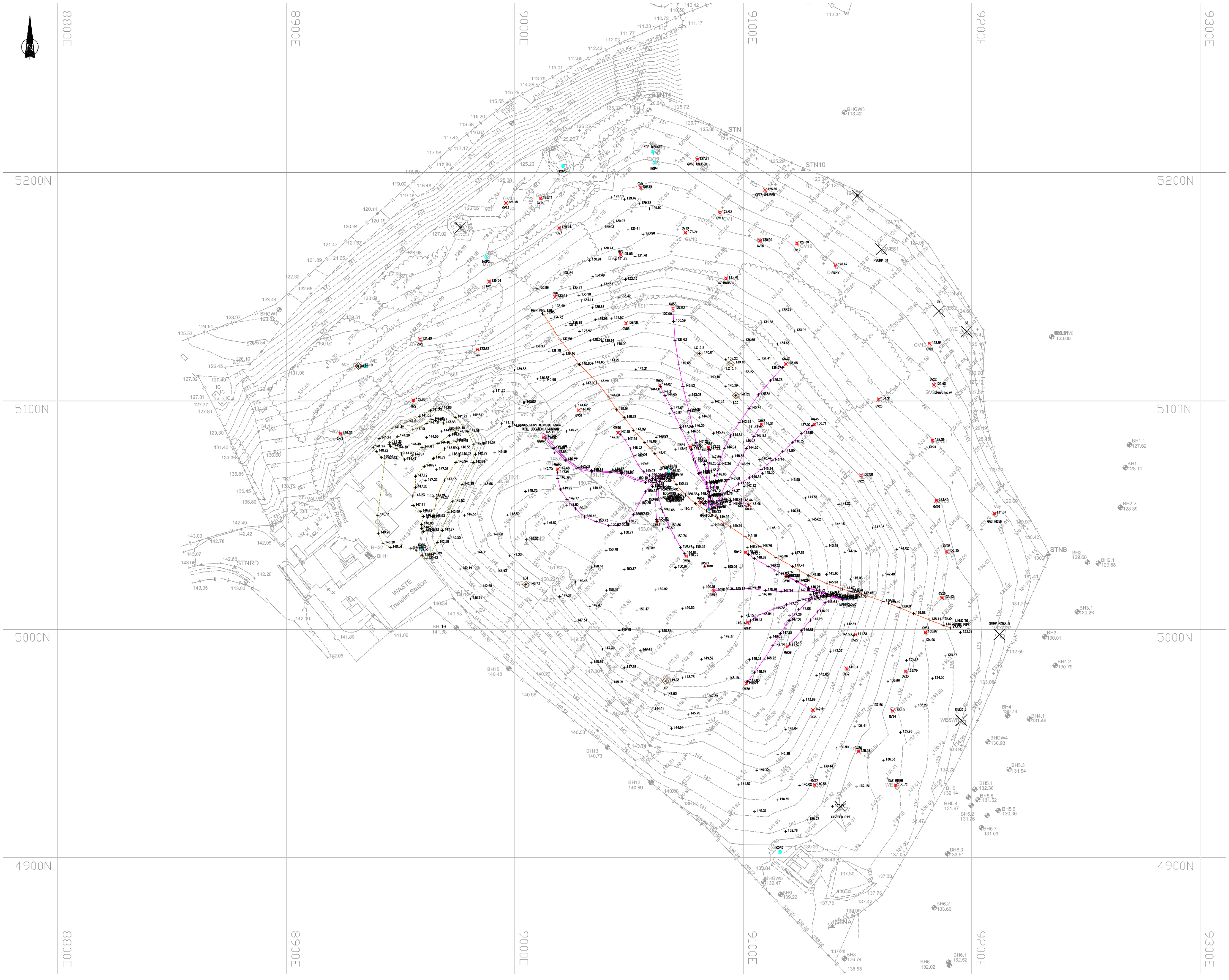
B.2 Carbon dioxide trigger level breach any monitoring point for 5 consecutive days

B.2.1 Instigate daily monitoring until carbon dioxide levels reduce below trigger levels, results of which should be forwarded daily to the EA.

B.2.2 If after 14 days of non-compliance, carbon dioxide levels are not reducing, or a reason for gas migration is not evident, inform the EA. Take gas samples as soon as practicable for confirmatory landfill gas chromatography analysis for methane, or trace analysis for carbon dioxide. A review of offsite monitoring measures should also be undertaken.

B.2.3 A review of existing gas control measures should also be carried out.

DRAWING



NOTES

REV	MODIFICATIONS	BY	CH	AP	DATE
A	BOREHOLE ANNOTATION AMENDED	IO	AKS	AKS	11.11.11

FLINTSHIRE COUNTY COUNCIL
WASTE MANGEMENT SERVICES

STANDARD LANDFILL SITE

SURVEY
17.03.2011

DRAWN BY: IO	DATE: 17.05.2011
CHECKED BY: JDM	SCALE @ A1: 1:750
APPROVED BY: AS	ISSUE: Fn / REVISION: A
DRAWING NUMBER: 1240/SURV/01	

Caulmert
Engineering, Environmental and Planning

WWW.CAULMERT.COM

Registered Office: Unit F13, InTec, Parc Menai, Bangor, Gwynedd, LL57 4FG Company Registered No: 06716319

APPENDIX 1

Landfill Gas Monitoring Checklist

LANDFILL GAS MONITORING CHECKLIST

Equipment and Maintenance

Gas monitoring will be carried out using an approved portable gas analyser, capable of reading methane, carbon dioxide, oxygen and atmospheric pressure.

The instruments will be serviced in accordance with the manufacturers' recommendations

A log of maintenance is to be kept by the contractor for inspection on demand

Landfill Gas Monitoring

Before leaving the office:-

(i) Check in-line hydrophobic filters and replace if necessary. Check the battery life is sufficient for the monitoring visit; and

(ii) Check the analyser is within its calibration date. Once a month verify the calibration with test gas and record on the log.

On site:-

(i) Record the date, atmospheric pressure, pressure trend, instrument type and serial number, name of technician and on-site weather.

(ii) During the course of the monitoring visit a visual inspection of the site and its surroundings should be carried out making a note of any vegetation die-back or leachate outbreaks.

At the borehole:-

(i) Record any damage to headworks, tap or cap in the site diary;

(ii) Attach sample tube to the sample tap, open tap, record atmospheric pressure then switch on analyser pump;

(iii) Once constant readings are obtained record readings;

(iv) Close gas tap, remove tube, allow pump to run to flush out any residual gas before taking the next sample;

(v) If water level data is required remove borehole cap and measure relative to cover level (or otherwise agreed borehole datum); and

(vi) Reseal borehole.

Reporting Result

(i) Inform the Site Manager of any results in excess of the trigger levels or any problems recorded as part of visual inspection. Leave a copy of data and compliance report on-site. Inform the Agency by fax or email of any breaches in trigger levels and the proposed actions, within 24 hours of the monitoring visit; and

(ii) Back at the office the data should be transferred to the Company's database. A field log for the visit should be created manually for the visit. A report should be printed and distributed to the Site Manager, and a copy kept on the site file.

APPENDIX 2

Gas Extraction System Maintenance

GAS EXTRACTION SYSTEM MAINTENANCE

The proposed gas field maintenance schedule will be as follows:

Maintenance Schedule – Gas Field

Weekly

1.1 Visual inspection of the gas extraction wells and strategic monitoring points

1.2 Replace all damaged / failed parts on extraction well heads or strategic monitoring points

Monthly

1.1 Visual inspection of all gas extraction pipe work and condensate de-watering pots.

1.2 Repair or replace any damaged parts. Inform site manager if contractors are required.

Service Schedule for Gas Extraction Equipment

1.0 General

Weekly

1.1 Complete all works as detailed on the site specific Weekly Service / Inspection checklist.

Annually

1.2 Contractors service / recalibration of gas analyser

1.3 Contractor inspection of all LV electrical systems

2.0 Gas Process / Flare Equipment

Monthly

2.1 Complete all works to Gas Process / Flare system Monthly Service Checklist.

Quarterly

2.2 Complete all works to Gas Process / Flare system Quarterly Service Checklist.

Bi-Annually

2.3 Complete all works to Gas Process / Flare system Bi-Annual Service Checklist.

Annually

2.3 Complete all works to Gas Process / Flare system Annual Service Checklist

APPENDIX 3

Carbon Dioxide Trigger Levels Derivation

STANDARD LANDFILL SITE

CARBON DIOXIDE TRIGGER LEVELS DERIVATION

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

1.1 Flintshire County Council Waste Management Services (FCC) appointed Caulmert Limited (Caulmert) to evaluate carbon dioxide (CO_2) concentrations in perimeter gas monitoring locations at Standard Landfill Site, and propose appropriate trigger levels to be used as part of the updated Landfill Gas Management Plan for the site.

1.2 In order to revise the trigger levels, monitoring data collected at perimeter gas monitoring wells between January 2004 and April 2011 was reviewed, and the range of background concentrations determined using statistical analysis. Separate trigger levels have been proposed for each monitoring location. This allows for most appropriate levels to be set for each well, ensuring that the risks are evaluated accurately.

2.0 DATA ANALYSIS

2.1 Routine landfill gas monitoring data collected at the 29 perimeter monitoring locations at Standard Landfill Site between January 2004 and April 2011 (as provided by FCC) was used in the evaluation.

2.2 Table 1 in Appendix 1 provides a summary of the methane and carbon dioxide concentrations detected within the perimeter monitoring locations during the review period.

2.3 In order to establish background carbon dioxide concentrations of the area it is important to exclude any data which is influenced by landfill gas migration occurrences. The presence of methane at a monitoring location was used as the determining factor when deciding if landfill gas migration has been detected at the specific location.

2.4 Table 1 shows that methane has not been detected or remained below instrumental error of 0.1 % in 19 of the 29 monitoring locations.

2.5 Methane has historically been detected at concentrations above 0.1 % in 10 of the 29 boreholes (namely STBH 3.0, STBH 4.0, STBH 4.1, STBH 5.0, STBH 9.0, STBH 12, STBH 13, STBH 15, STBH 16 and STBH 22). The methane concentrations detected in these boreholes has been plotted in time series graphs, included in Appendix 1. The graphs reveal that methane concentrations in locations STBH 3.0, STBH 4.0, STBH 4.1, STBH 5.0, STBH 9.0, STBH 12, STBH 13 and STBH 15 have remained below 1.0 % since at least August 2009.

2.6 Methane concentrations in two boreholes, STBH 16 and STBH 22, have exceeded 1.0 % as recently as March 2011. Concentrations in STBH 22 remain particularly high, with an average of 20.7 % between 2004 and 2011.

2.7 Little evidence of landfill gas migration has been observed in the majority of the monitoring locations during the review period.

2.8 Evidence of landfill gas migration, as indicated by the detection of significant methane concentrations, has been identified within boreholes STBH 16 and STBH 22. These boreholes have methane trigger levels of 10 % and 40 % respectively, which have been agreed with the Environment Agency. Although evidence of gas migration has been identified within them, carbon dioxide trigger levels for these boreholes have been derived in the same way as for the boreholes with no evidence of landfill gas migration. The level derived for these locations will provide an indication as to increasing carbon dioxide concentration within them and will trigger an action plan as described in the Landfill Gas Management Plan.

3.0 DERIVATION OF CARBON DIOXIDE TRIGGER LEVELS

3.1 Carbon dioxide concentrations for all boreholes have been plotted in time series graphs (included in Appendix 2). The statistical analysis, on which the determination of the trigger levels is based, was performed on the original data set.

3.2 Table 2 in Appendix 2 shows the summary statistics that were calculated for the data collected during the review period for each separate borehole.

3.3 The mean value (average) of the data represents generally the middle value of the data. The standard deviation reflects the spread of the values from the mean. It can be seen that the spread of data is different at the different locations reflecting the difference between the CO_2 generating potential of the strata through which different boreholes have been installed.

3.4 When setting a trigger level, it needs to be considered, that if the carbon dioxide concentrations are generally normally distributed, and if a value is taken at $\mu+\sigma$ then the probability of a concentration of carbon dioxide exceeding this value due to natural variation would be 0.1587, i.e. in a large dataset, 15.87% of the values would be expected to be greater than this trigger level. The respective probabilities when larger dispersion of the data is allowed (by having more than σ added to the average value) are as follows:

$\mu+1.19\sigma$	p=0.1, 10% of values would exceed it
$\mu+1.65\sigma$	p=0.05, 5% of values would exceed it
$\mu+2\sigma$	p = 0.0228, 2.5% of values would exceed it
$\mu+3\sigma$	p = 0.0013, <1% of values would exceed it

4.0 PROPOSED TRIGGER LEVELS

4.1 The figures within Table 2 in Appendix 2 give the background concentrations of carbon dioxide which is likely to be present at each of the investigated locations. The figure for background concentration should be such as to encompass the majority of concentrations recorded during monitoring which are likely to be generated due to natural variation within the strata, but be able to detect concentrations which are unlikely to be due to natural variation alone. Any uncharacteristic increases in the concentration of the determinant can be detected, and investigated. Therefore, it is proposed the background concentration at each location is calculated using $\mu+1.65\sigma$. In this case it is expected that the background concentration used incorporates 95% of all concentrations resulting from natural variation.

4.2 it is proposed that the following calculation is used to determine the trigger levels:

Trigger level = background concentration + 1.5% = (μ+1.65σ) +1.5%.

The proposed trigger levels for the perimeter gas monitoring wells are included in Table 3:

Table 3: Proposed carbon dioxide trigger levels for specific monitoring locations

Location	Carbon Dioxide Trigger Level (% v/v)
STBH 1	5.37
STBH 1.1	5.35
STBH 2.0	7.05
STBH 2.1	7.57
STBH 2.2	5.82
STBH 3.0	6.70
STBH 3.1	7.76
STBH 4.0	10.65
STBH 4.1	7.12
STBH 4.2	8.59
STBH 5.0	19.42
STBH 5.1	5.80
STBH 5.2	9.64
STBH 5.3	6.00
STBH 6.0	8.92
STBH 6.1	3.72
STBH 6.2	6.12
STBH 6.3	8.24
STBH 7.0	6.20
STBH 7.1	5.49
STBH 7.2	4.46
STBH 9.0	10.72
STBH 12	6.48
STBH 13	5.20
STBH 15	8.30
STBH 16	6.82
STBH 22	31.27
STMBH 5.4	16.03
STMBH 5.5	17.06
STMBH 5.7	7.07

5.0 CONCLUSIONS

5.1 Caulmert was appointed by FCC to review the trigger levels for carbon dioxide for perimeter gas monitoring locations around Standard Landfill Site and suggest trigger levels for carbon dioxide. Routine monitoring data collected since January 2004 for 29 monitoring locations was analysed and its statistical characteristics determined.

5.2 The results of the statistical analysis were used to propose borehole specific trigger levels for CO_2 detected at the perimeter gas boreholes present at the site.

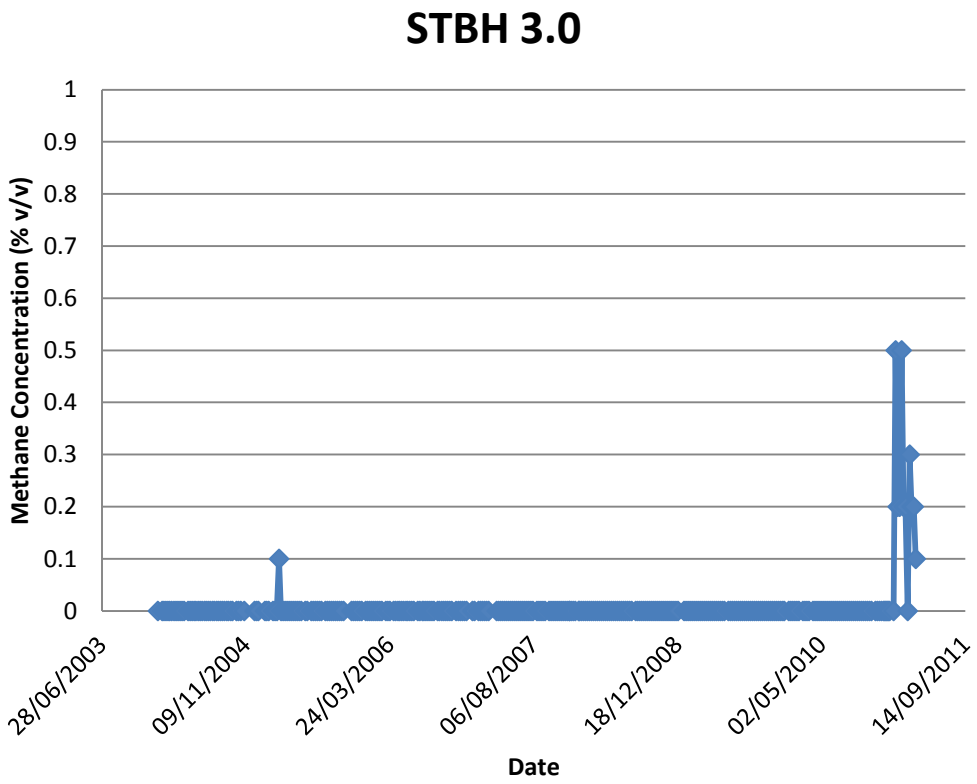
5.3 The proposed trigger levels, if approved, will form part of the EP monitoring compliance limits for the site, and should be used in conjunction with the Landfill Gas Management Plan for the site, which details actions to be carried out if any exceedances of the proposed trigger levels are detected.

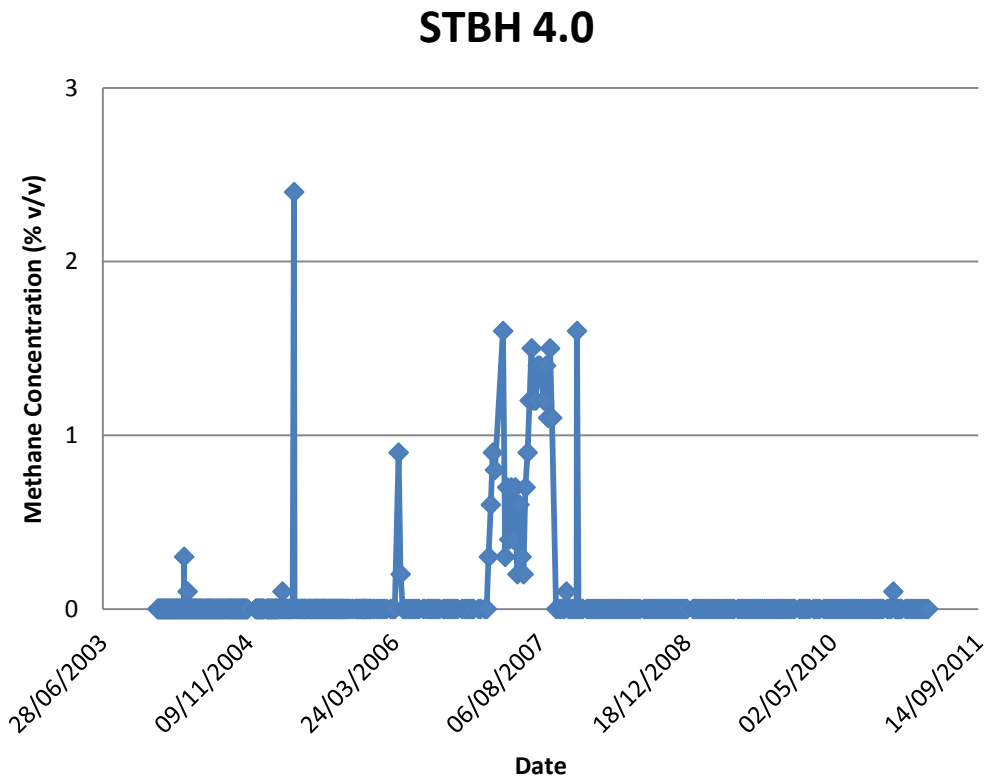
APPENDIX A

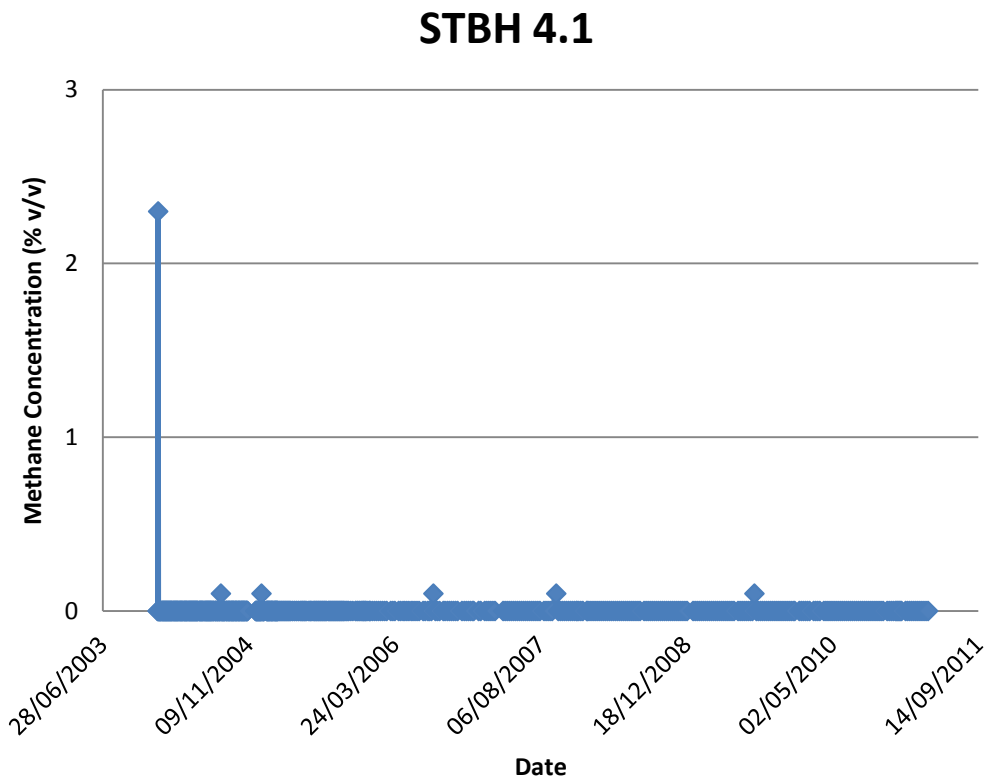
Summary of Landfill Gas Concentrations and Methane Graphs

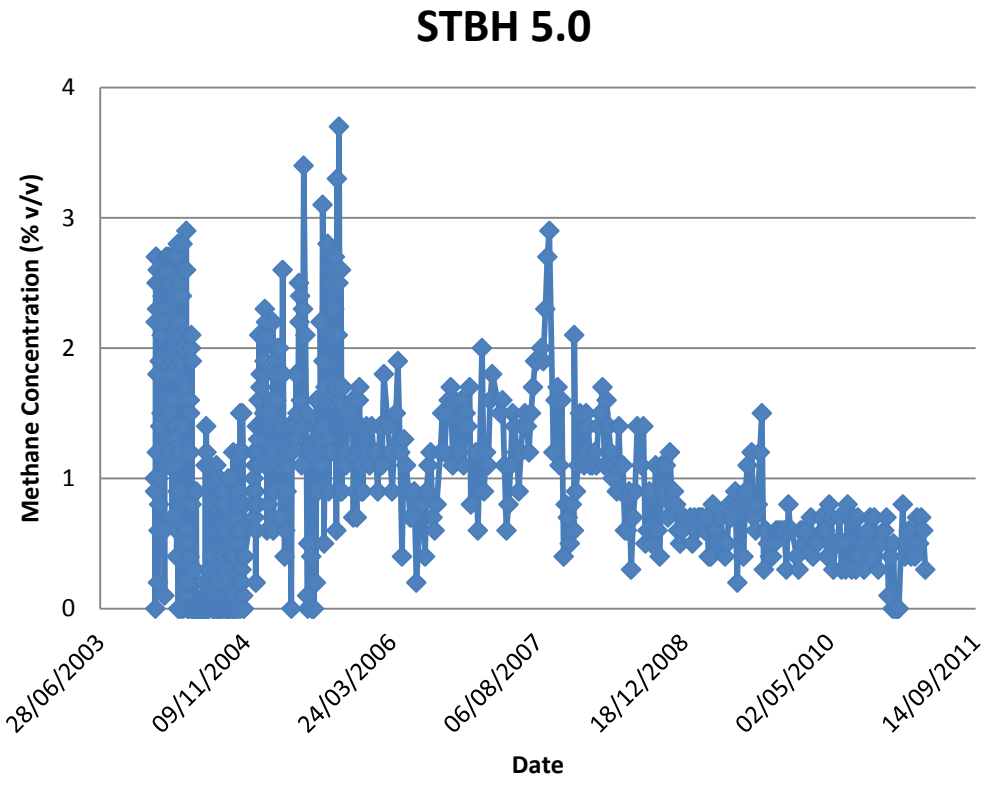
Table 1: Landfill Gas Monitoring Summary (2004 – 2011)

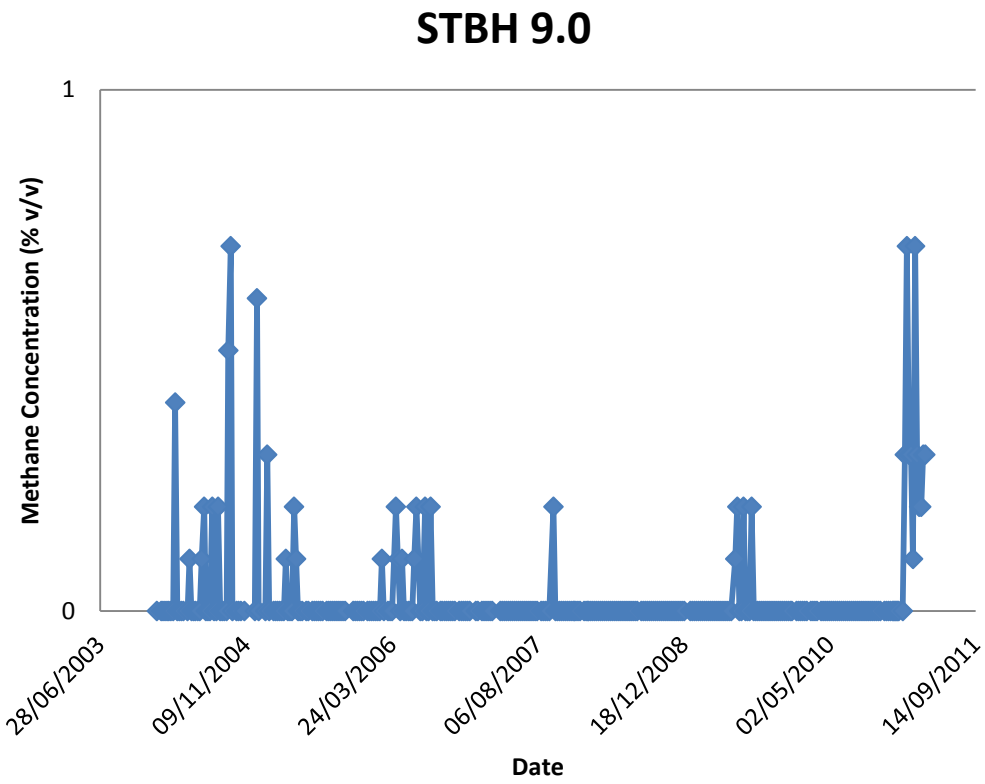
Sample Point	Methane (% v/v)				Carbon Dioxide (% v/v)			
	Min	Max	Average	Count	Min	Max	Average	Count
STBH 1.0	0.00	0.00	0.00	346	0.00	8.30	1.83	346
STBH 1.1	0.00	0.10	0.00	725	0.00	5.20	1.68	725
STBH 2.0	0.00	0.10	0.00	303	0.60	7.90	3.62	303
STBH 2.1	0.00	0.10	0.00	726	0.00	9.90	3.28	726
STBH 2.2	0.00	0.10	0.00	726	0.00	6.30	2.27	726
STBH 3.0	0.00	0.50	0.01	346	0.00	6.40	2.57	346
STBH 3.1	0.00	0.00	0.00	411	0.00	23.40	2.99	411
STBH 3.2	0.00	0.00	0.00	316	0.00	7.80	3.48	316
STBH 4.0	0.00	2.40	0.04	727	0.00	21.60	3.71	727
STBH 4.1	0.00	2.30	0.00	727	0.00	15.30	2.23	727
STBH 4.2	0.00	0.10	0.00	727	0.00	11.60	3.74	727
STBH 5.0	0.00	3.70	1.00	727	0.00	24.70	10.20	727
STBH 5.1	0.00	0.10	0.00	727	0.00	13.90	2.16	727
STBH 5.2	0.00	0.10	0.00	727	0.00	11.20	4.02	727
STBH 5.3	0.00	0.10	0.00	727	0.00	14.30	1.98	727
STBH 6.0	0.00	0.10	0.00	346	0.00	12.50	2.61	346
STBH 6.1	0.00	0.00	0.00	726	0.00	8.20	1.09	726
STBH 6.2	0.00	0.10	0.00	727	0.00	8.60	2.17	727
STBH 6.3	0.00	0.10	0.00	727	0.00	17.20	4.02	727
STBH 7.0	0.00	0.10	0.00	346	0.00	9.60	1.63	346
STBH 7.1	0.00	0.10	0.00	411	0.00	13.90	1.59	411
STBH 7.2	0.00	0.10	0.00	316	0.00	6.90	0.89	316
STBH 8.0	0.00	0.00	0.00	26	0.00	11.20	3.43	26
STBH 9.0	0.00	0.70	0.03	346	0.00	18.70	2.47	346
STBH 10	0.00	0.40	0.27	3	0.00	2.50	1.37	3
STBH 12	0.00	2.10	0.02	346	0.00	15.30	1.20	346
STBH 13	0.00	8.00	0.23	727	0.00	13.60	0.87	727
STBH 15	0.00	0.60	0.02	346	0.00	13.80	2.81	346
STBH 16	0.00	7.70	0.21	727	0.00	11.00	1.56	727
STBH 22	0.00	36.70	20.73	727	0.60	32.10	21.65	727
STMBH	0.00	0.10	0.00	684	0.00	17.90	8.09	684
STMBH	0.00	0.10	0.00	727	0.00	17.20	9.51	727
STMBH	0.00	0.10	0.00	522	0.00	12.70	1.73	522
STMBH	0.00	0.10	0.00	684	0.00	5.90	3.32	684

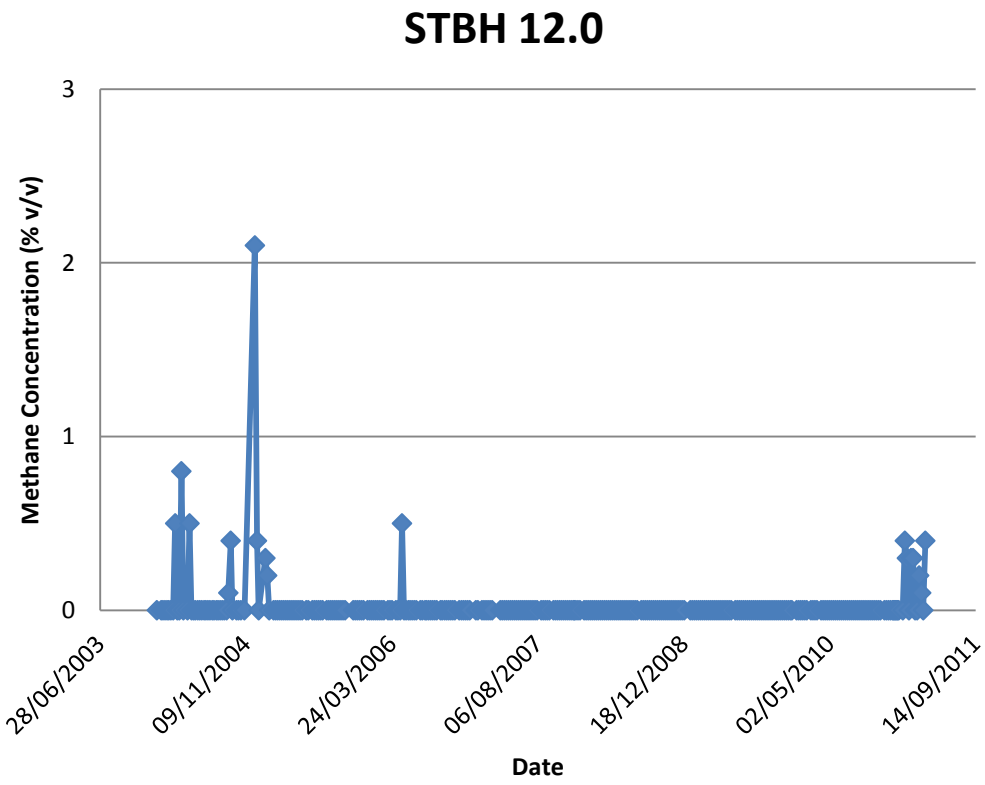

STBH 3.0
Methane Concentration (% v/v)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date

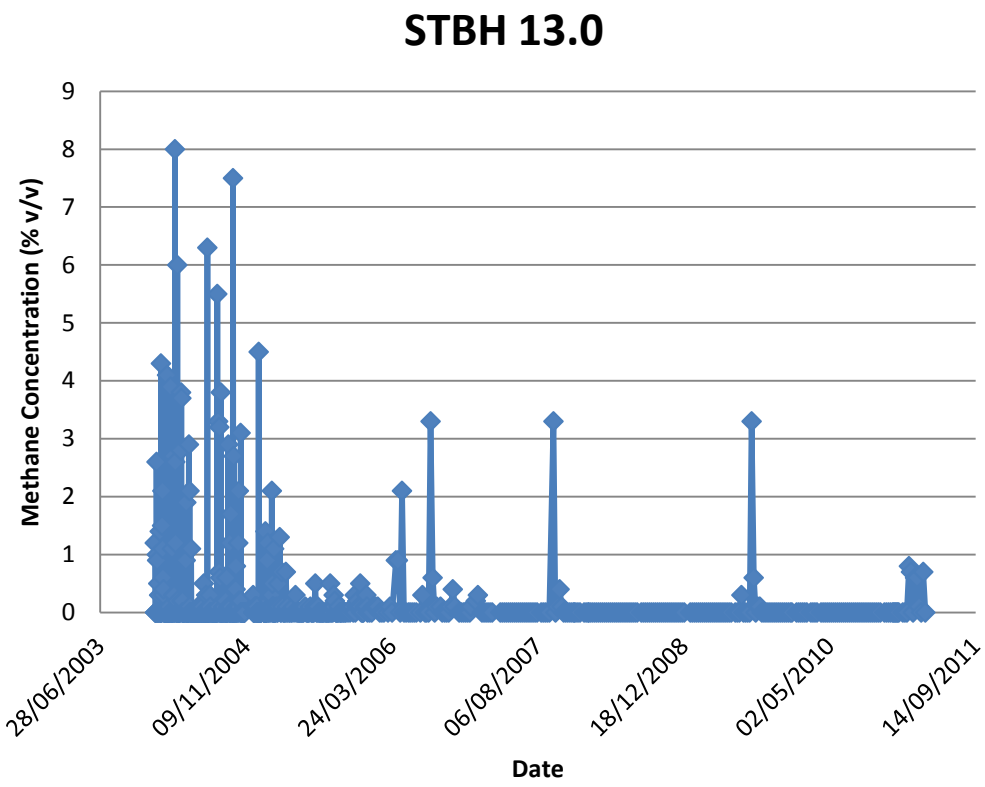

STBH 4.0
Methane Concentration (% v/v)
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date

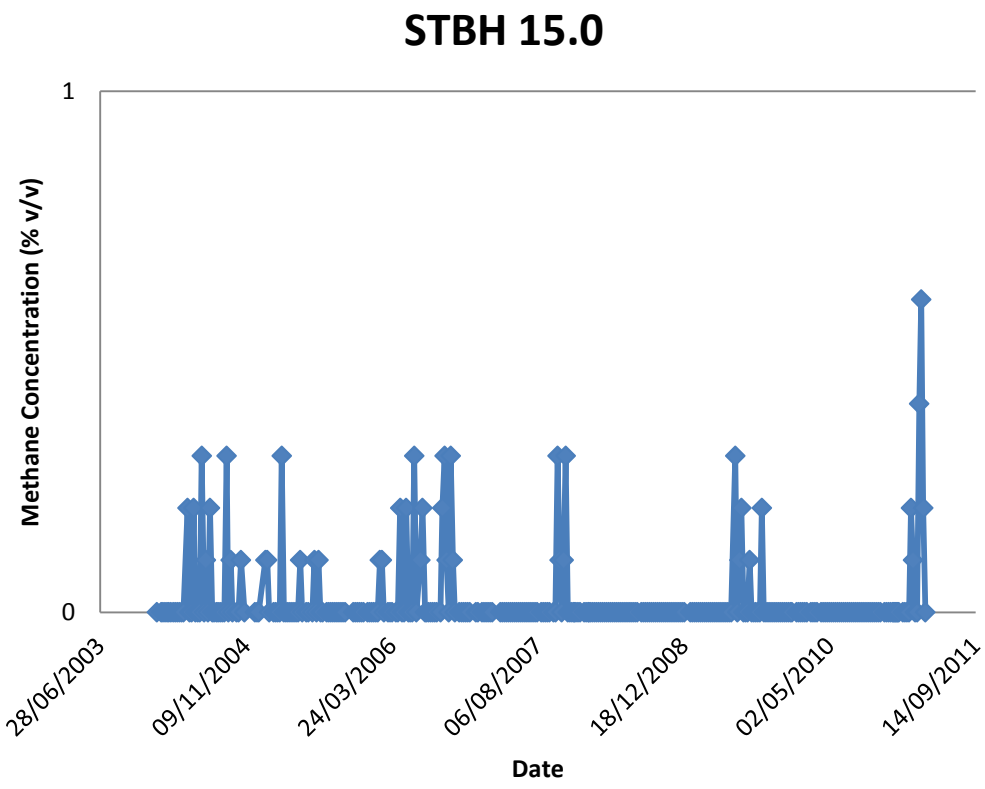

STBH 4.1
Methane Concentration (% v/v)
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date

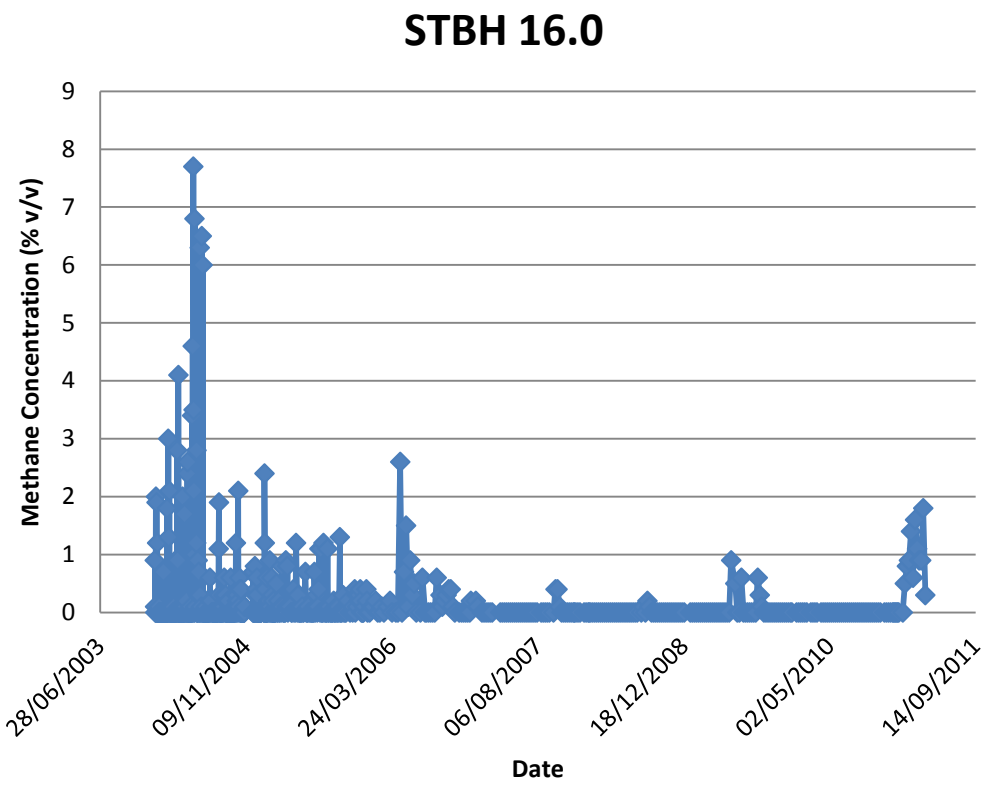

STBH 5.0
Methane Concentration (% v/v)
4
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date

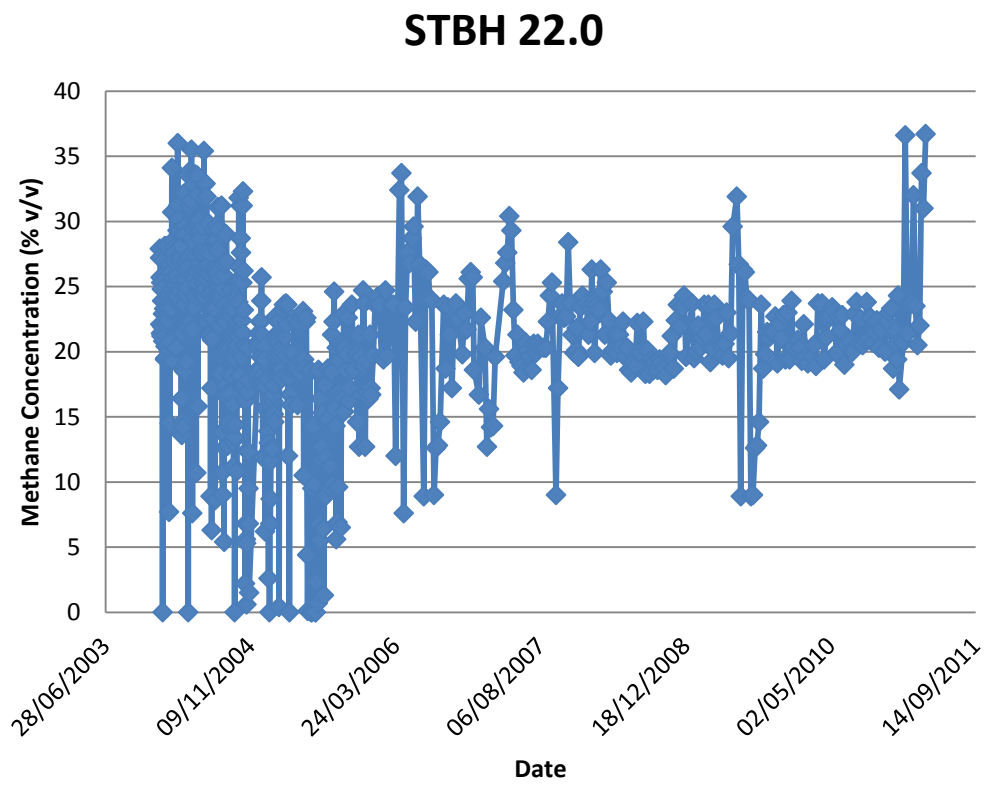

STBH 9.0
Methane Concentration (% v/v)
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date


STBH 12.0
Methane Concentration (% v/v)
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date


STBH 13.0
Methane Concentration (% v/v)
9
8
7
6
5
4
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date


STBH 15.0
Methane Concentration (% v/v)
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date


STBH 16.0
Methane Concentration (% v/v)
9
8
7
6
5
4
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date


STBH 22.0
Methane Concentration (% v/v)
40
35
30
25
20
15
10
5
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011
Date

APPENDIX B

Summary Statistics and Carbon Dioxide Graphs

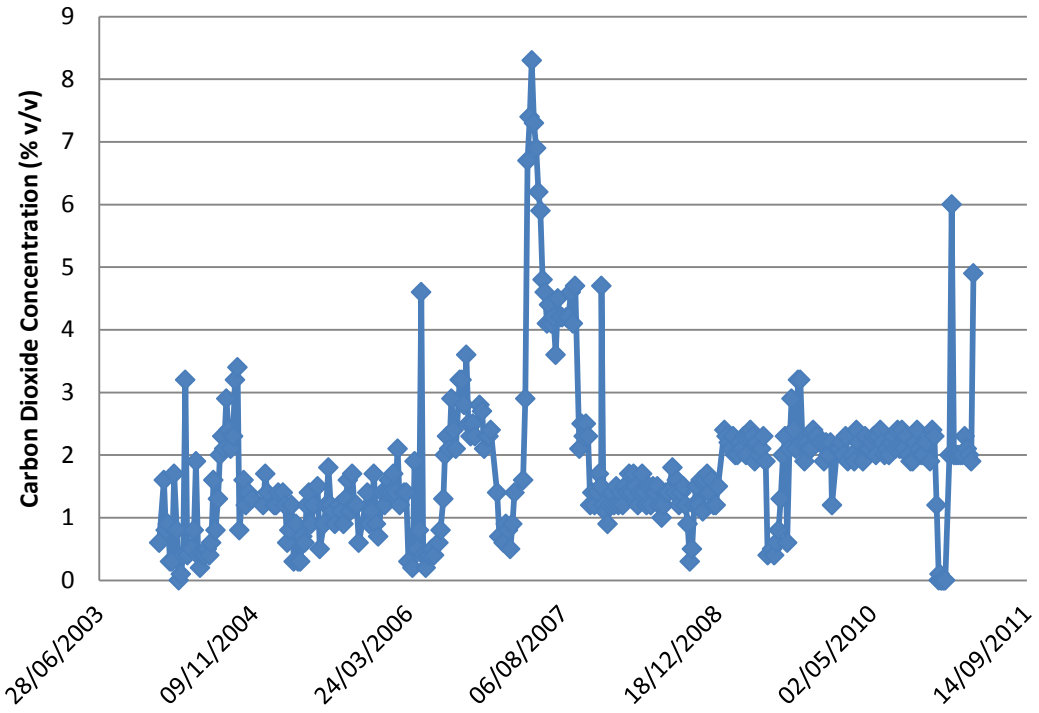
Table 2: Summary Statistics

Location	STBH 1	STBH 1.1	STBH 2.0	STBH 2.1	STBH 2.2	STBH 3.0	STBH 3.1	STBH 4.0	STBH 4.1	STBH 4.2
Minimum	0	0	0.6	0	0	0	0	0	0	0
25th percentile	1.2	0.8	3	2.3	1.2	1.1	2.1	1.7	0.7	2
Average	1.832081	1.682759	3.618482	3.284022	2.271074	2.566012	2.987591	3.713618	2.22586	3.743054
75th percentile	2.2	2.1	4.3	4.1	2.9	4.1	3.4	4.5	3.4	5.4
Maximum	8.3	5.2	7.9	9.9	6.3	6.4	23.4	21.6	15.3	11.6
Standard Deviation	1.236022	1.313968	1.170437	1.689585	1.241297	1.595985	1.984296	3.294627	2.054671	2.027702
Number	346	725	303	726	726	346	411	727	727	727
av+1 SD	3.068103	2.996727	4.788919	4.973607	3.512371	4.161997	4.971887	7.008245	4.28053	5.770755
av+1.19 SD	3.302947	3.24638	5.011302	5.294628	3.748217	4.465234	5.348904	7.634224	4.670918	6.156018
av+1.65 SD	3.871517	3.850806	5.549702	6.071837	4.319214	5.199387	6.26168	9.149752	5.616066	7.088761
av+2 SD	4.304125	4.310694	5.959355	6.663191	4.753668	5.757982	6.956183	10.30287	6.335201	7.798457
av+3 SD	5.540147	5.624662	7.129792	8.352776	5.994964	7.353967	8.94048	13.5975	8.389872	9.826158

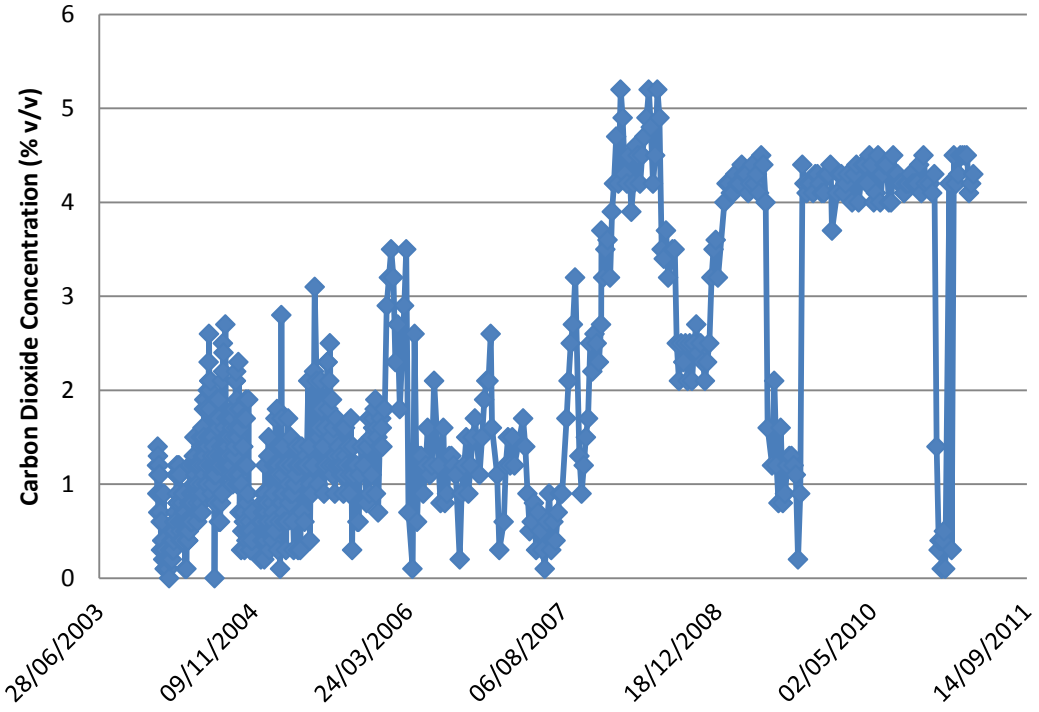
Location	STBH 5.0	STBH 5.1	STBH 5.2	STBH 5.3	STBH 6.0	STBH 6.1	STBH 6.2	STBH 6.3	STBH 7.0	STBH 7.1
Minimum	0	0	0	0	0	0	0	0	0	0
25th percentile	6.4	1.4	1.35	0.9	0.6	0.6	1.1	3.2	0.3	0.7
Average	10.19697	2.158459	4.02077	1.984182	2.61185	1.090083	2.172352	4.023659	1.626879	1.585401
75th percentile	14.2	2.7	5.7	2.7	4.375	1.4	3.1	4.9	2.1	2.1
Maximum	24.7	13.9	11.2	14.3	12.5	8.2	8.6	17.2	9.6	13.9
Standard Deviation	4.678456	1.297818	2.498483	1.526347	2.914592	0.682944	1.482624	1.645929	1.863781	1.460047
Number	727	727	727	727	346	726	727	727	346	411
av+1 SD	14.87543	3.456278	6.519254	3.510529	5.526441	1.773026	3.654976	5.669588	3.49066	3.045449
av+1.19 SD	15.76434	3.702863	6.993966	3.800535	6.080214	1.902785	3.936675	5.982314	3.844779	3.322858
av+1.65 SD	17.91643	4.29986	8.143268	4.502654	7.420926	2.216939	4.618682	6.739441	4.702118	3.994479
av+2 SD	19.55389	4.754096	9.017737	5.036876	8.441033	2.45597	5.1376	7.315516	5.354441	4.505496
av+3 SD	24.23234	6.051915	11.51622	6.563223	11.35562	3.138913	6.620224	8.961445	7.218223	5.965543

Location	STBH 7.2	STBH 9.0	STBH 12	STBH 13	STBH 15	STBH 16	STBH 22	STMBH 5.4	STMBH 5.5	STMBH 5.7
Minimum	0	0	0	0	0	0	0.6	0	0	0
25th percentile	0.1	0.3	0.3	0	0.4	0	18.6	5.2	6	2.3
Average	0.885759	2.46763	1.197688	0.867538	2.806452	1.557772	21.65103	8.090205	9.514168	3.324415
75th percentile	1.1	2.8	0.9	0.9	5.5	2.75	25.4	11.05	12.4	4.5
Maximum	6.9	18.7	15.3	13.6	13.8	11	32.1	17.9	17.2	5.9
Standard Deviation	1.256104	4.091673	2.293304	1.715853	2.421913	2.278736	4.923046	3.903114	3.664254	1.361369
Number	316	346	346	727	341	727	727	684	727	684
av+1 SD	2.141863	6.559303	3.490991	2.583391	5.228365	3.836507	26.57408	11.99332	13.17842	4.685785
av+1.19 SD	2.380523	7.336721	3.926719	2.909403	5.688528	4.269467	27.50946	12.73491	13.87463	4.944445
av+1.65 SD	2.958331	9.218891	4.981639	3.698695	6.802609	5.317685	29.77406	14.53034	15.56019	5.570675
av+2 SD	3.397967	10.65098	5.784295	4.299244	7.650278	6.115243	31.49712	15.89643	16.84268	6.047154
av+3 SD	4.654071	14.74265	8.077598	6.015097	10.07219	8.393978	36.42017	19.79955	20.50693	7.408524

STBH 1



STBH 1.1



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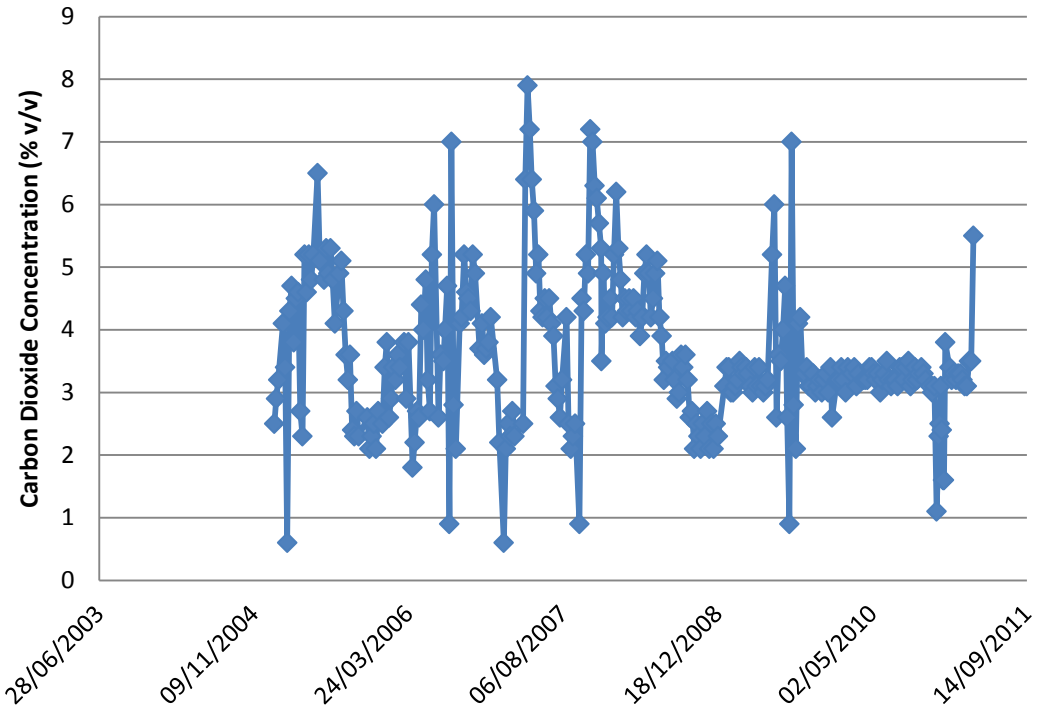

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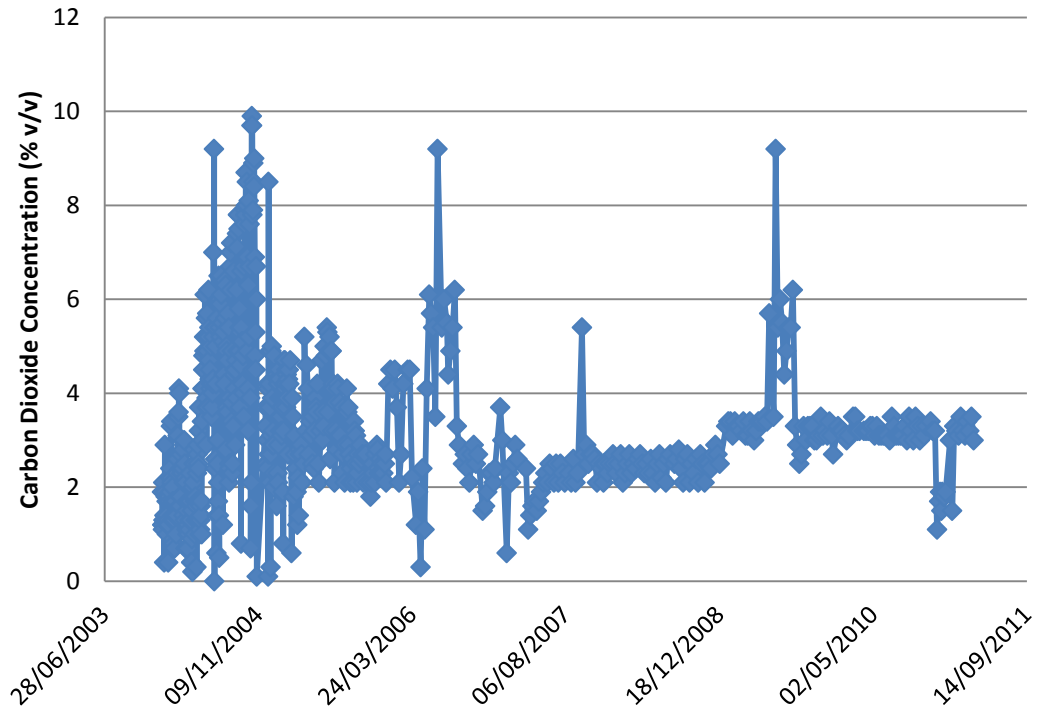

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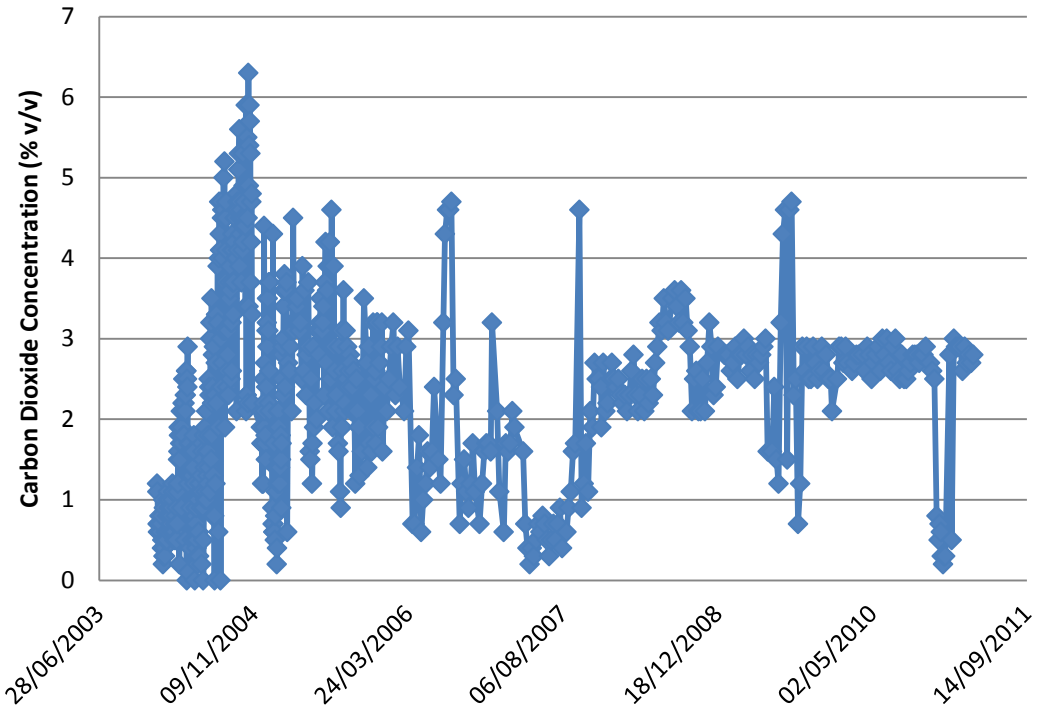

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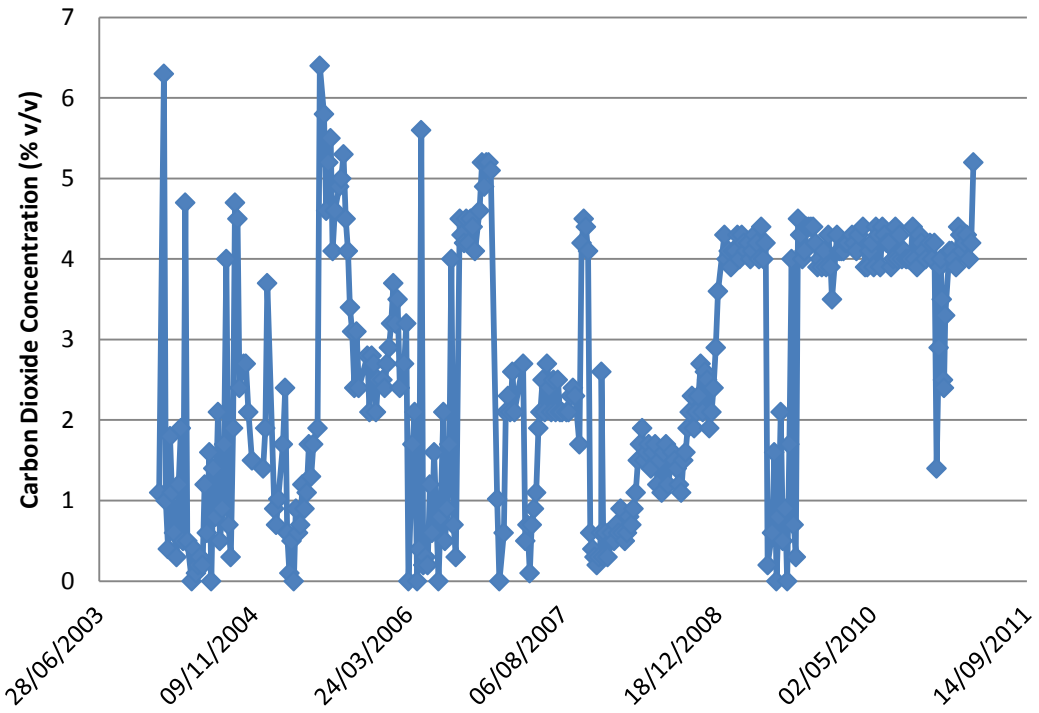
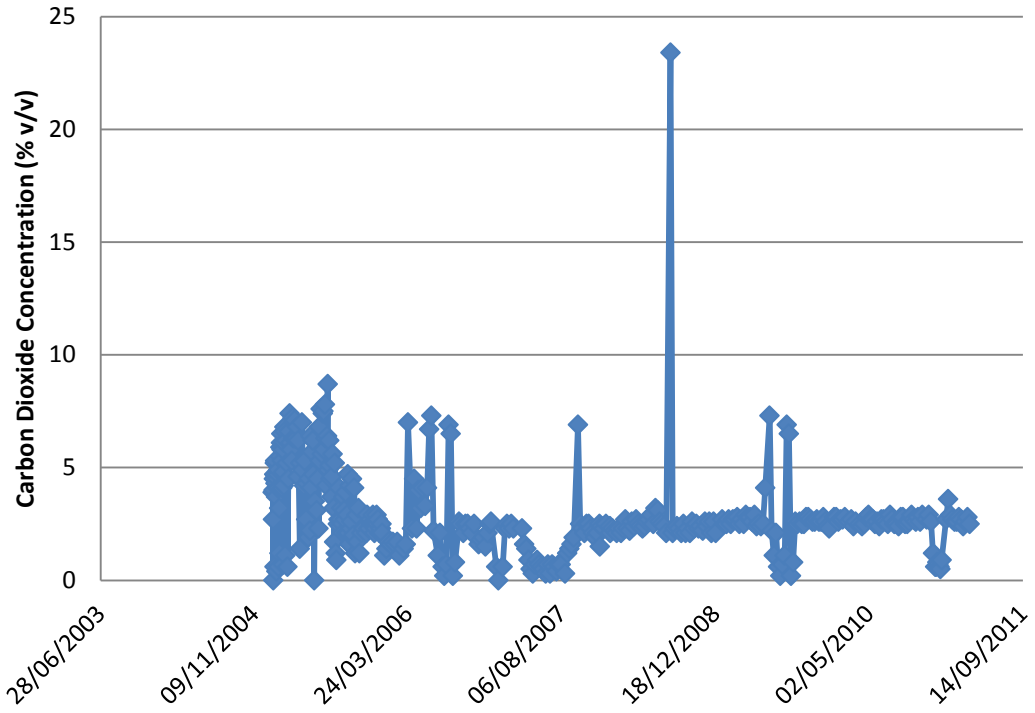


STBH 3.1



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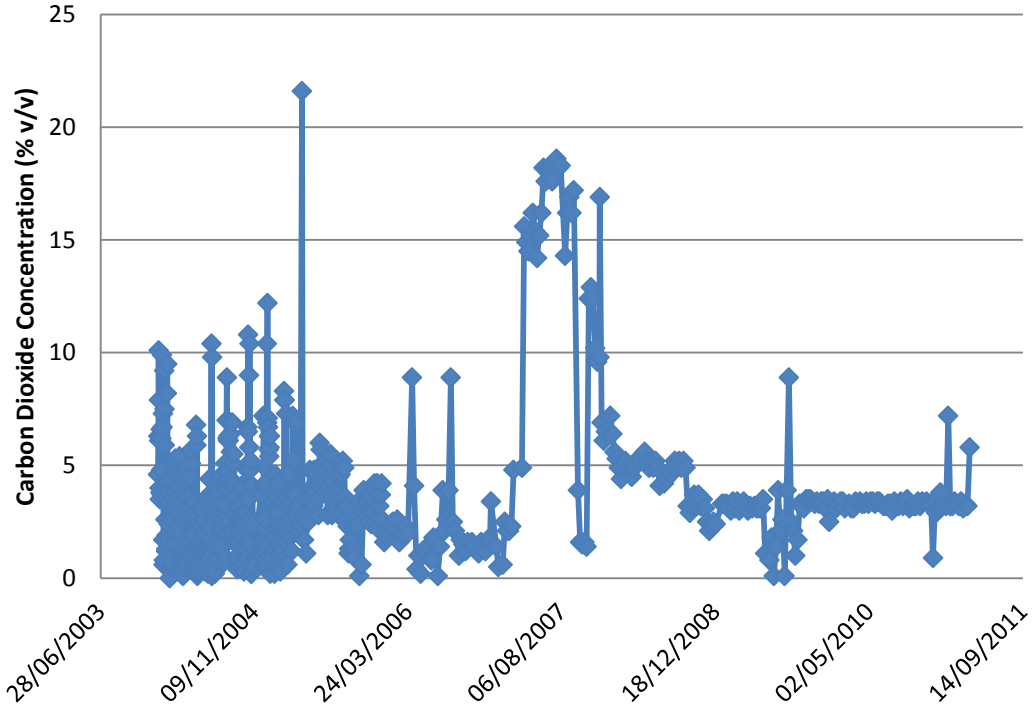

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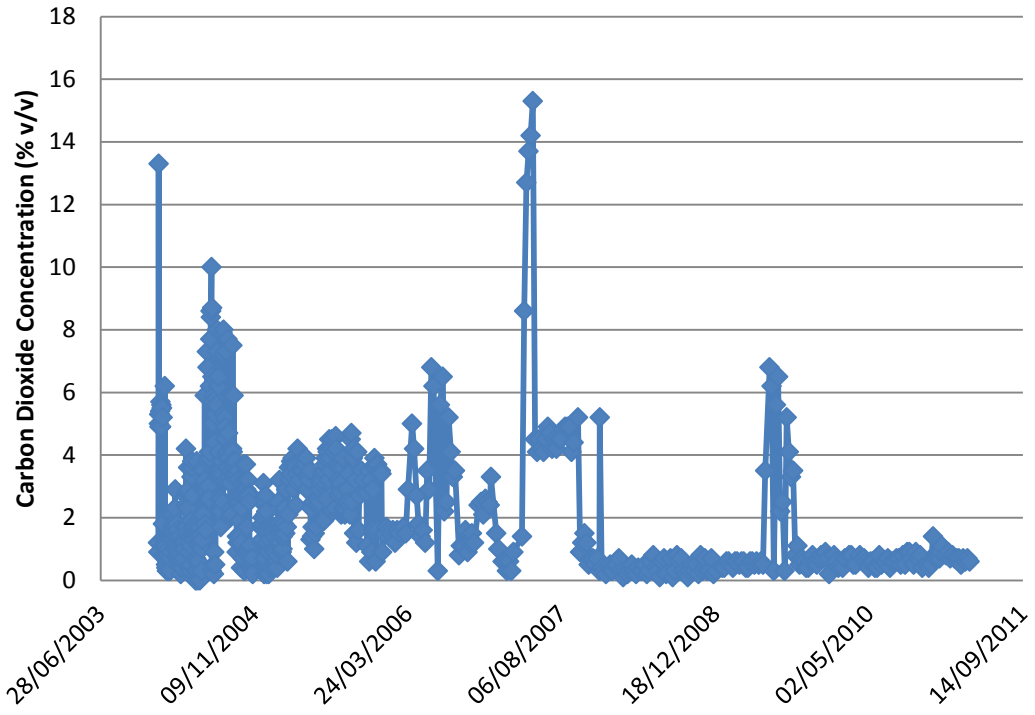

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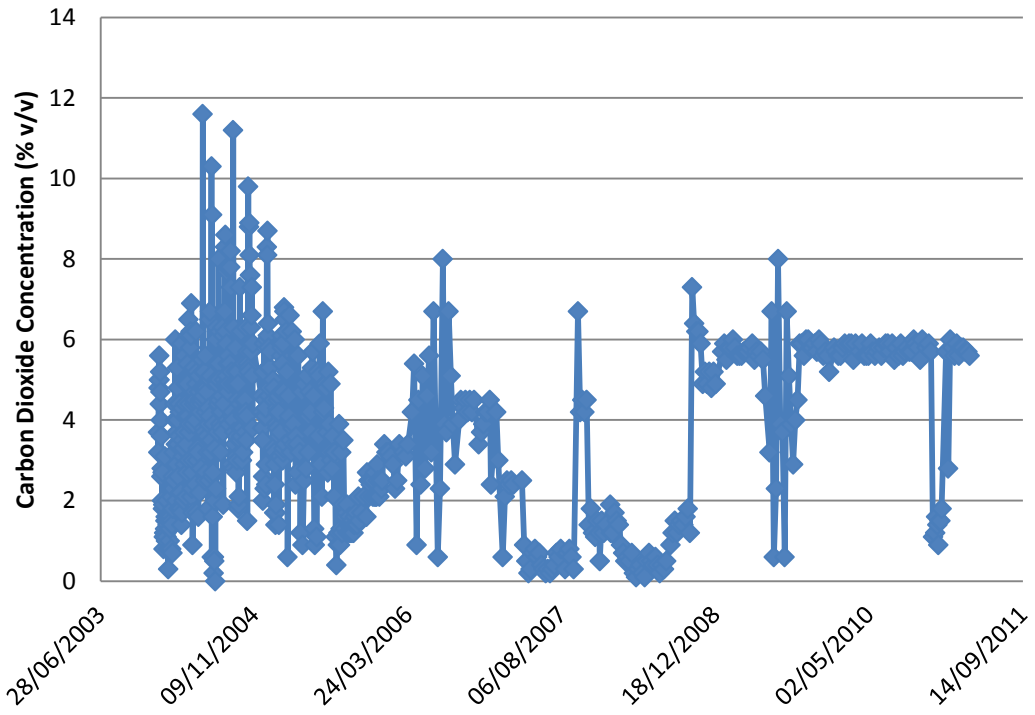

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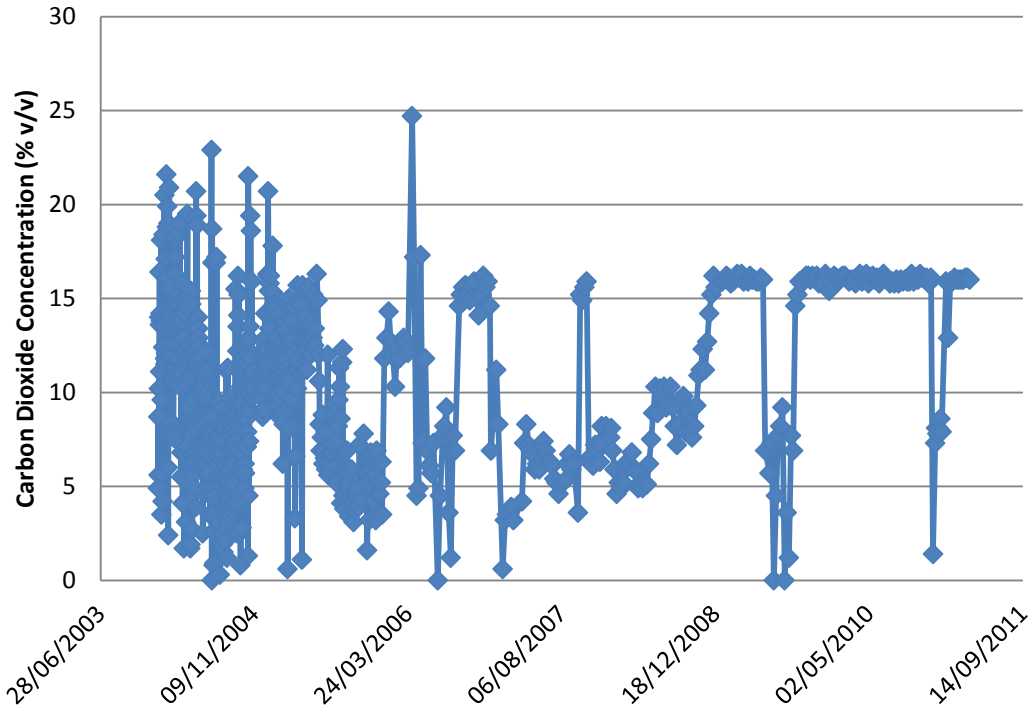

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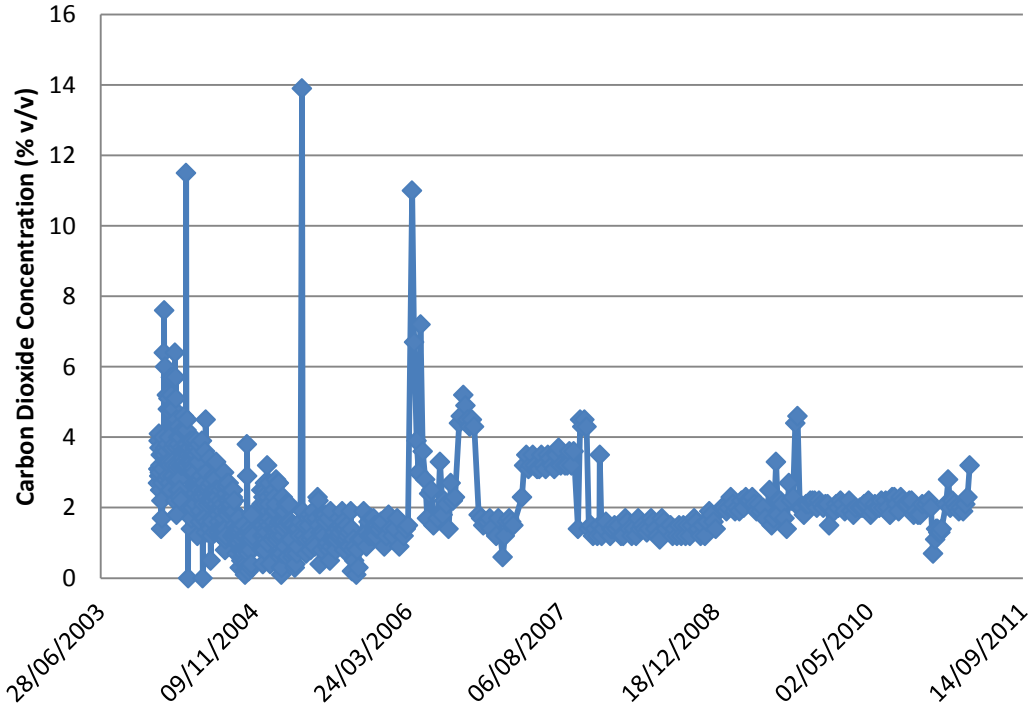

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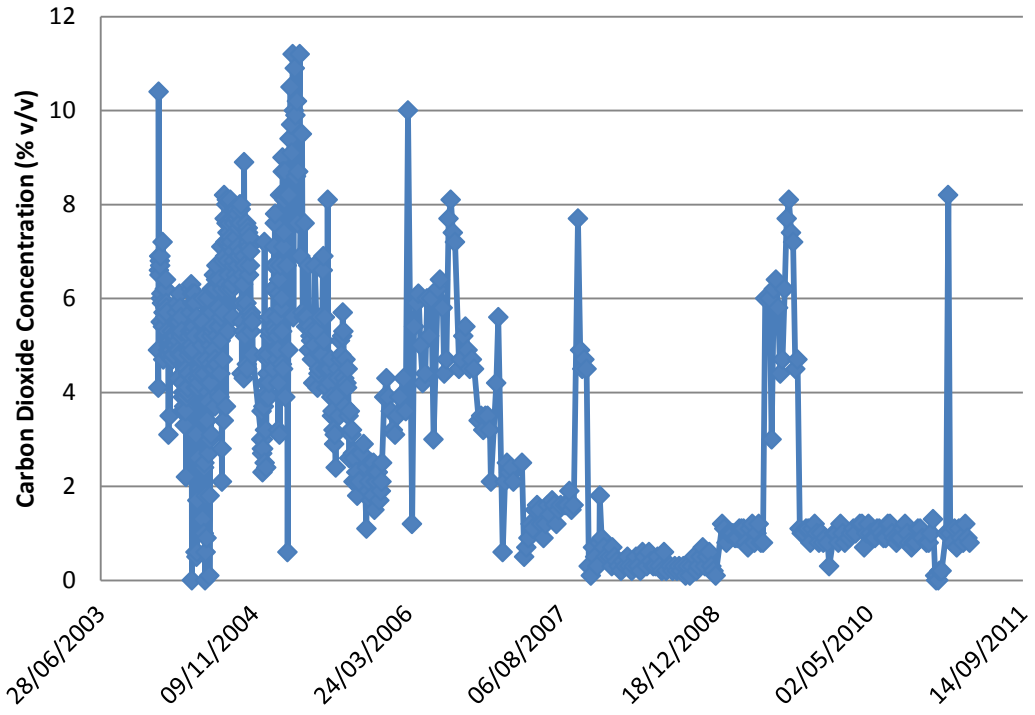

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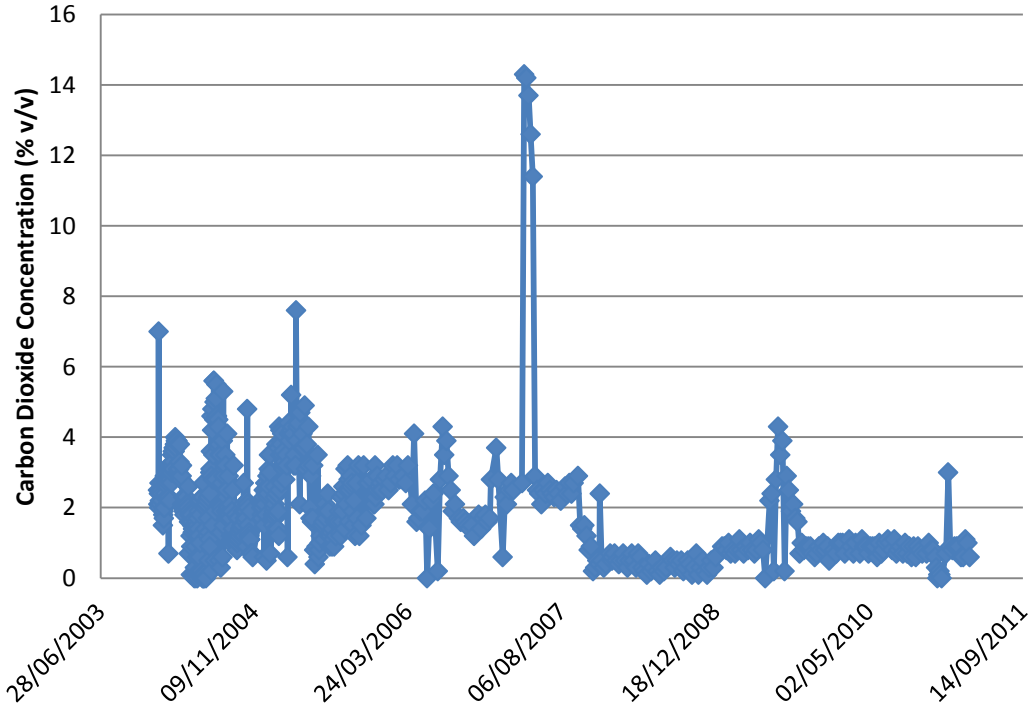

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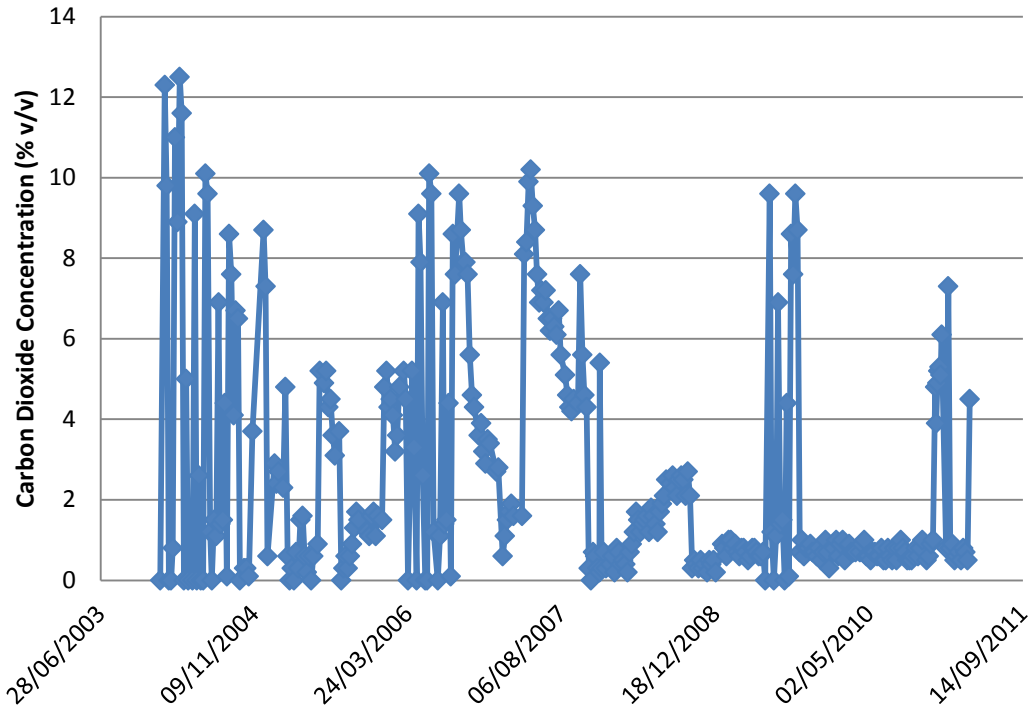

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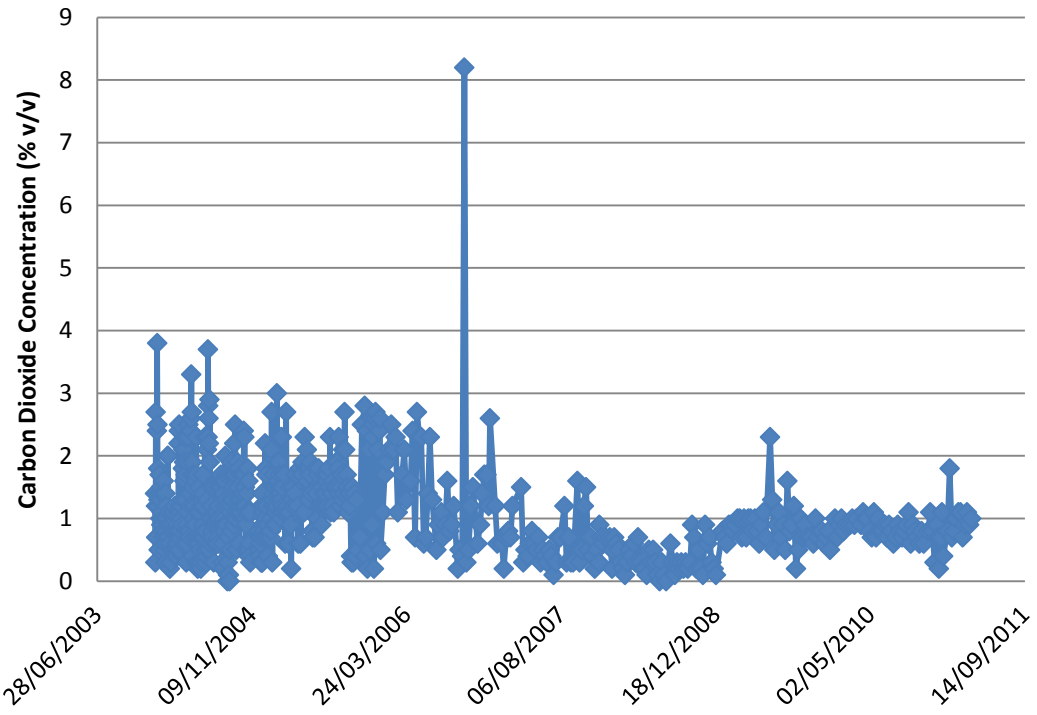

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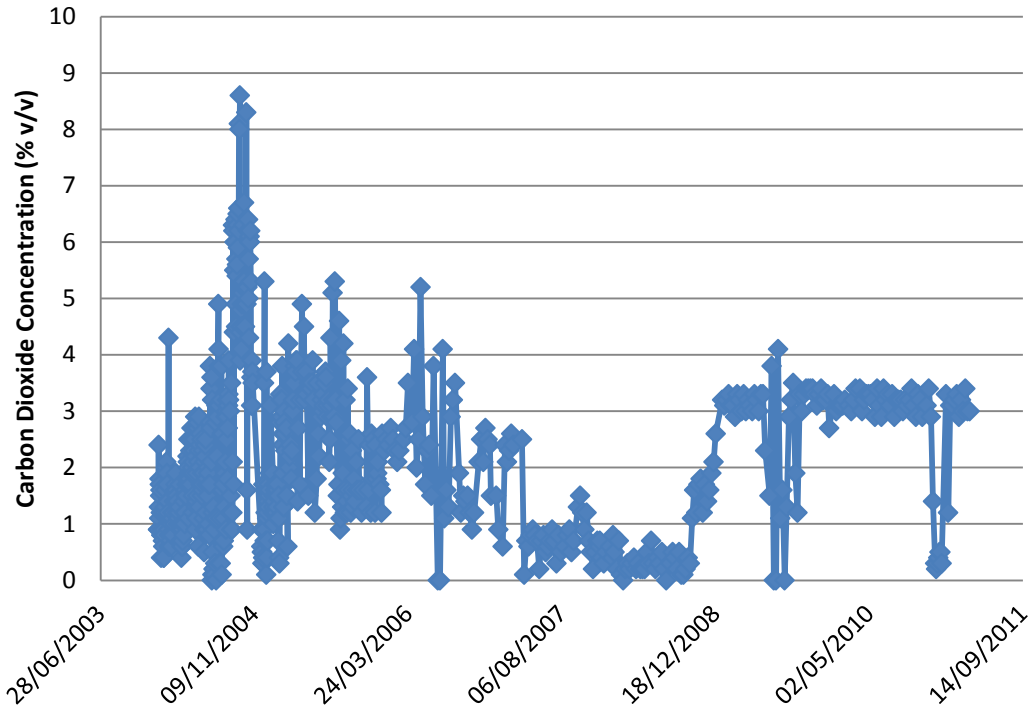

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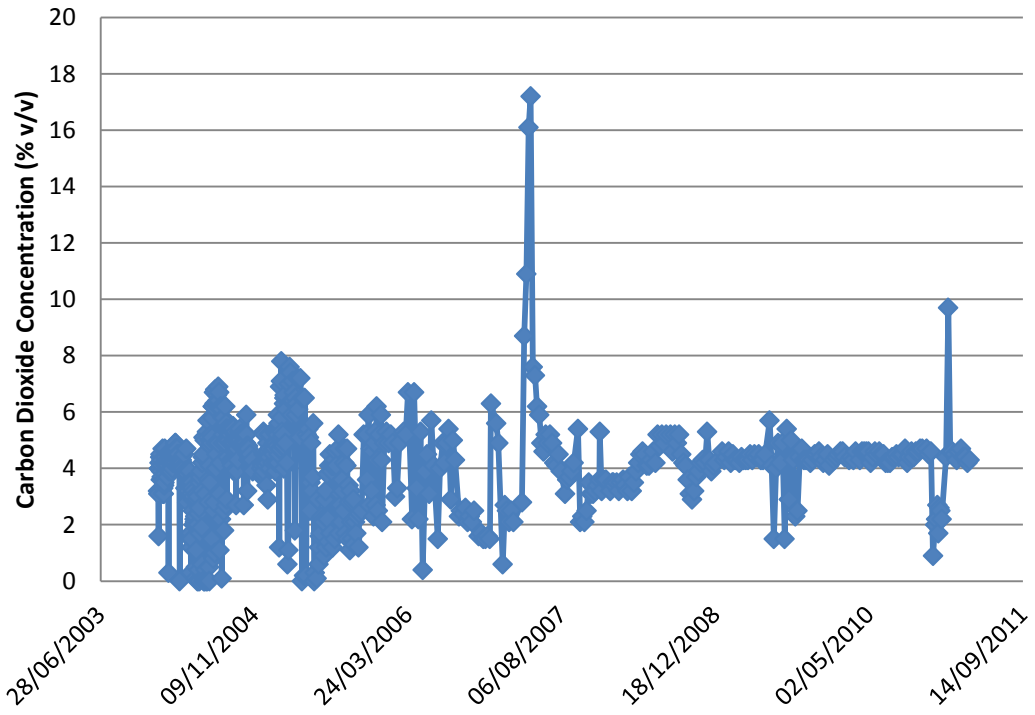
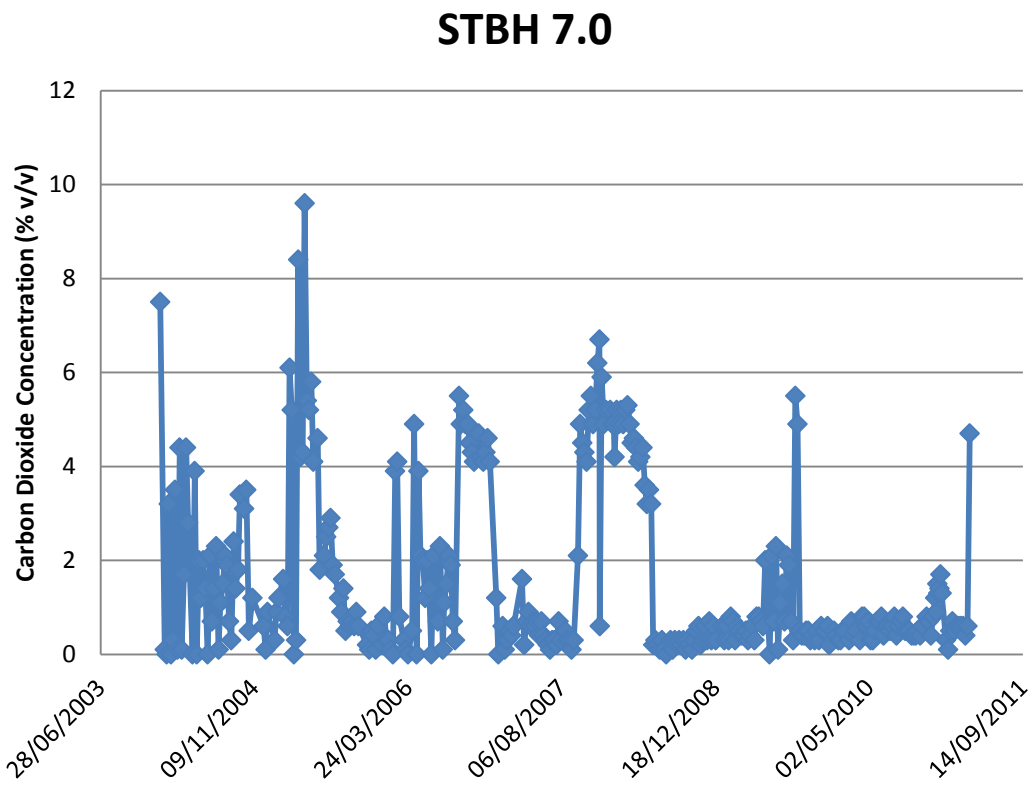
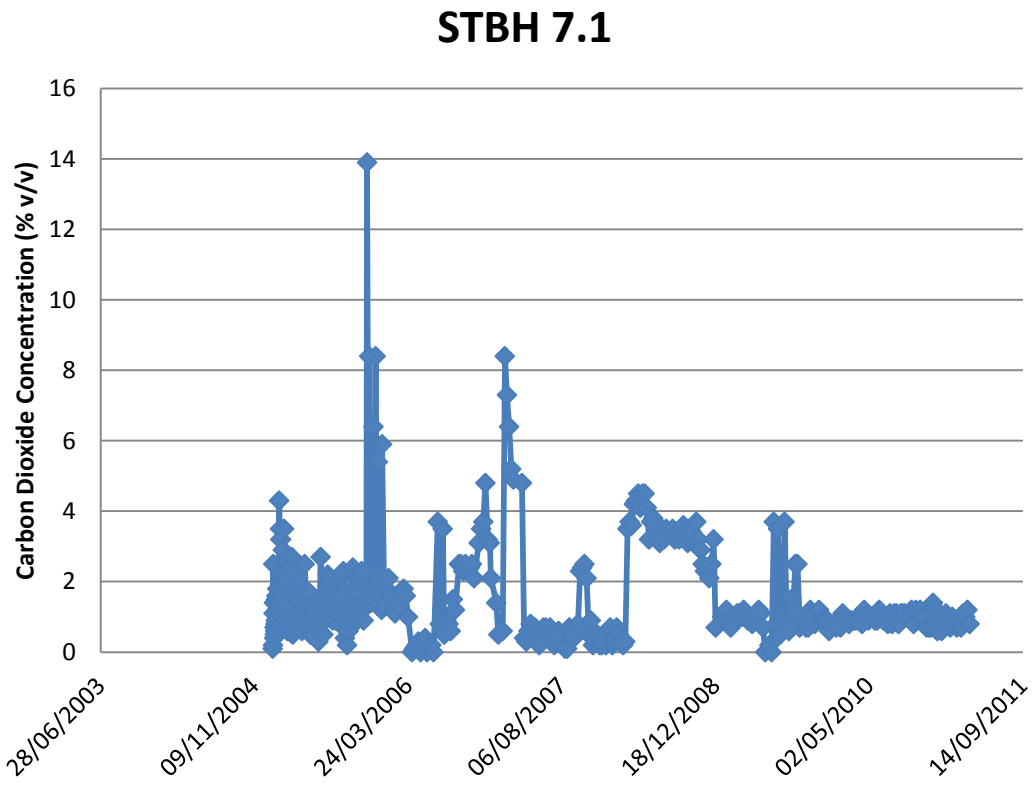



STBH 7.0
Carbon Dioxide Concentration (% v/v)
0
2
4
6
8
10
12
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011


STBH 7.1
Carbon Dioxide Concentration (% v/v)
0
2
4
6
8
10
12
14
16
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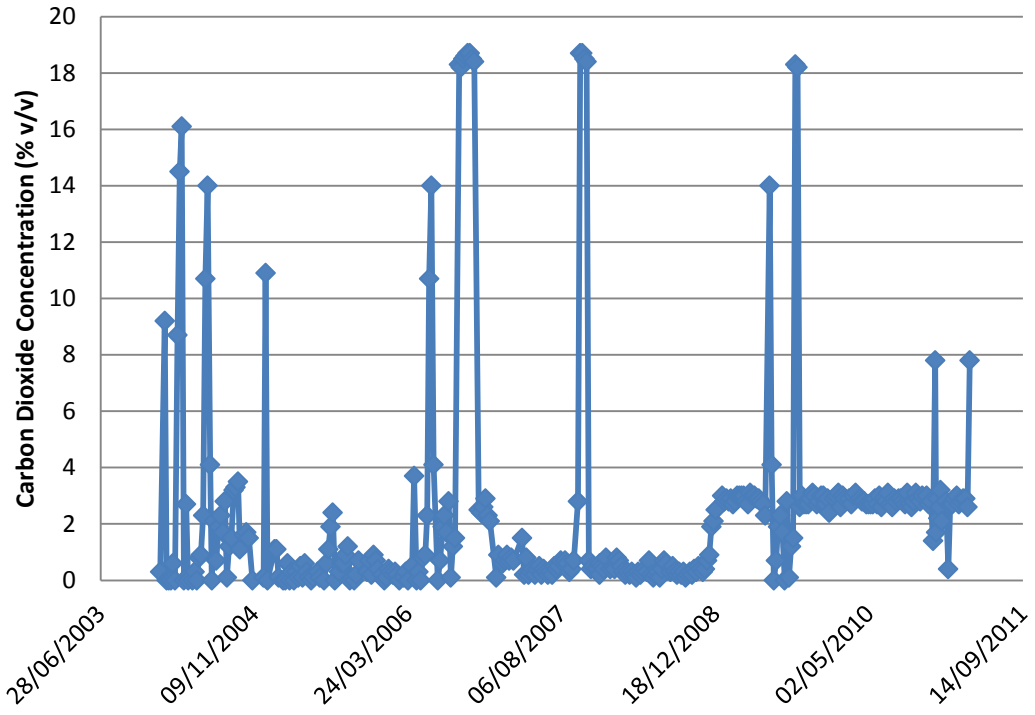
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011

STBH 9.0



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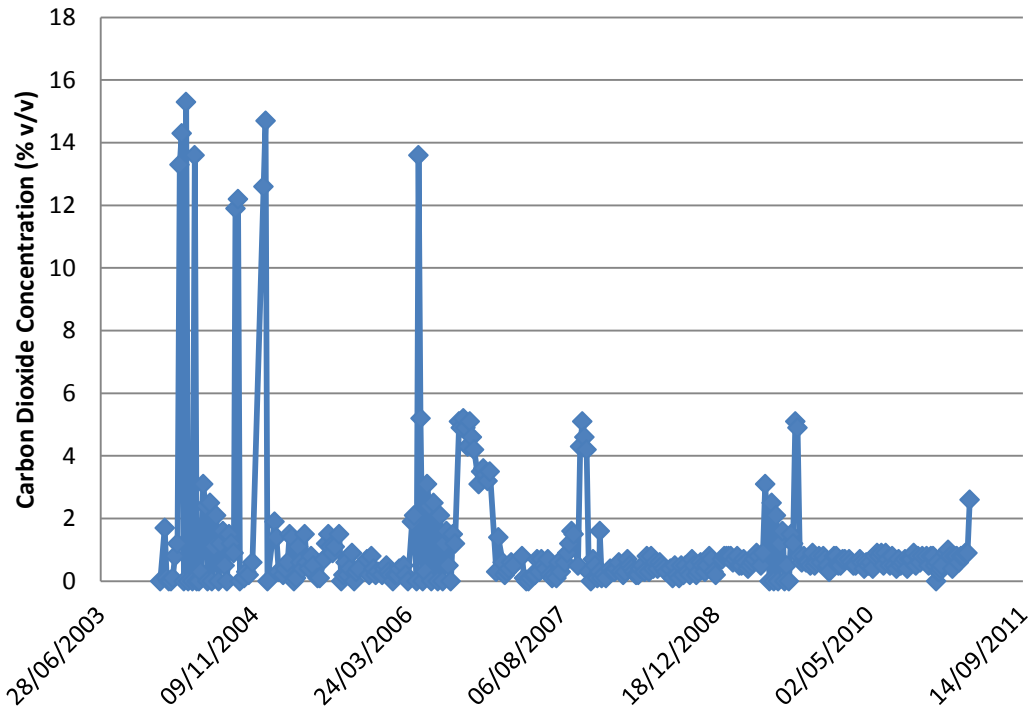
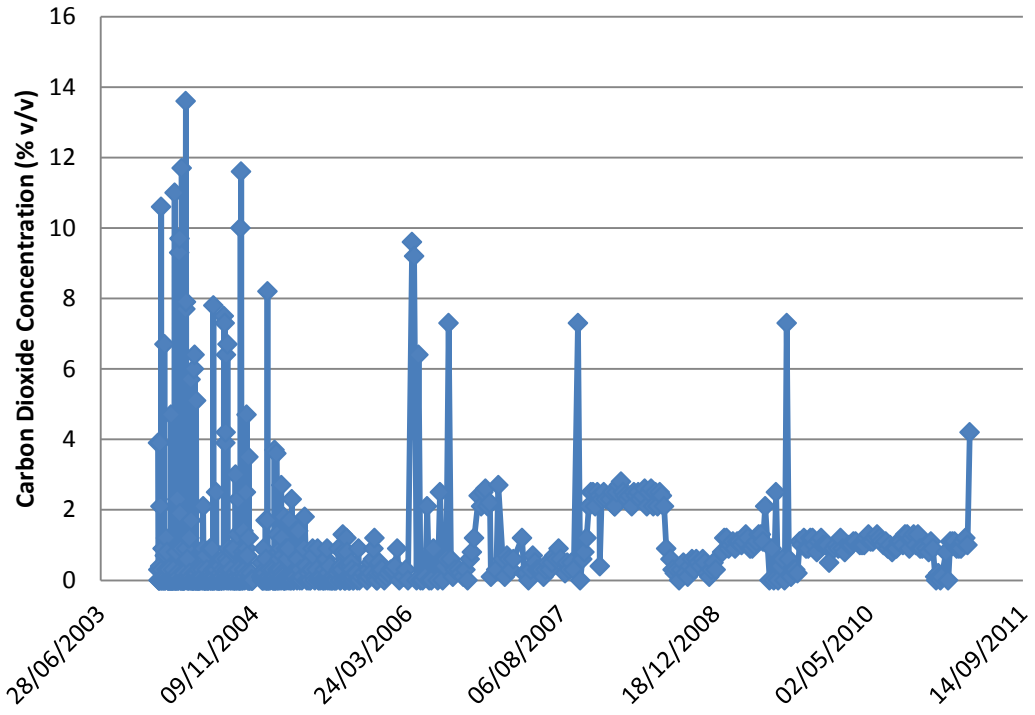
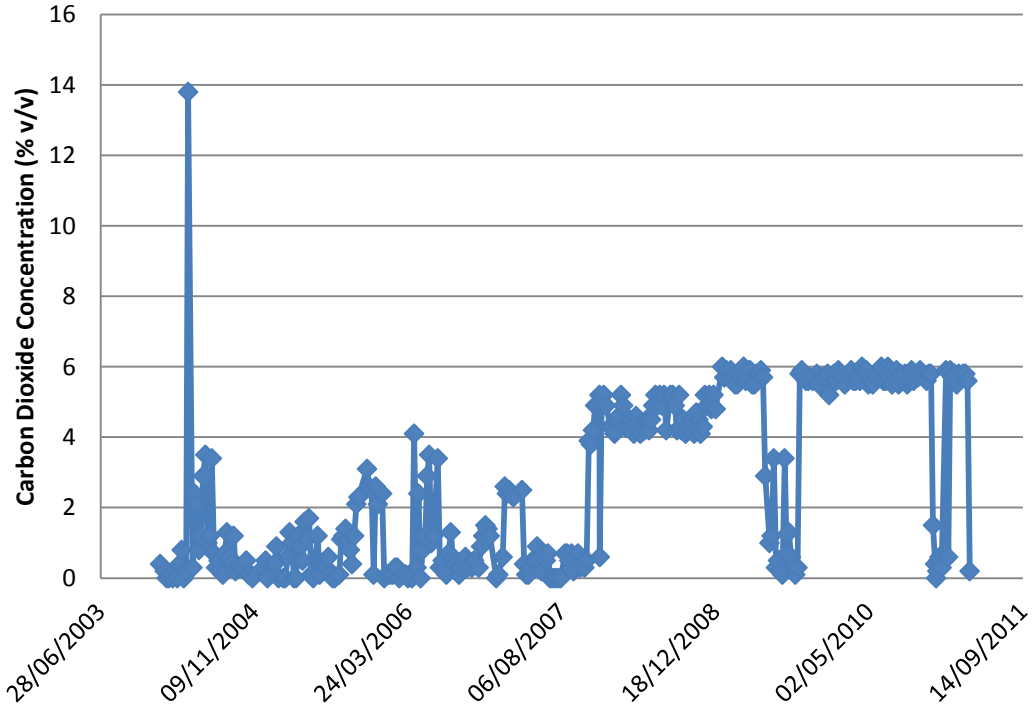


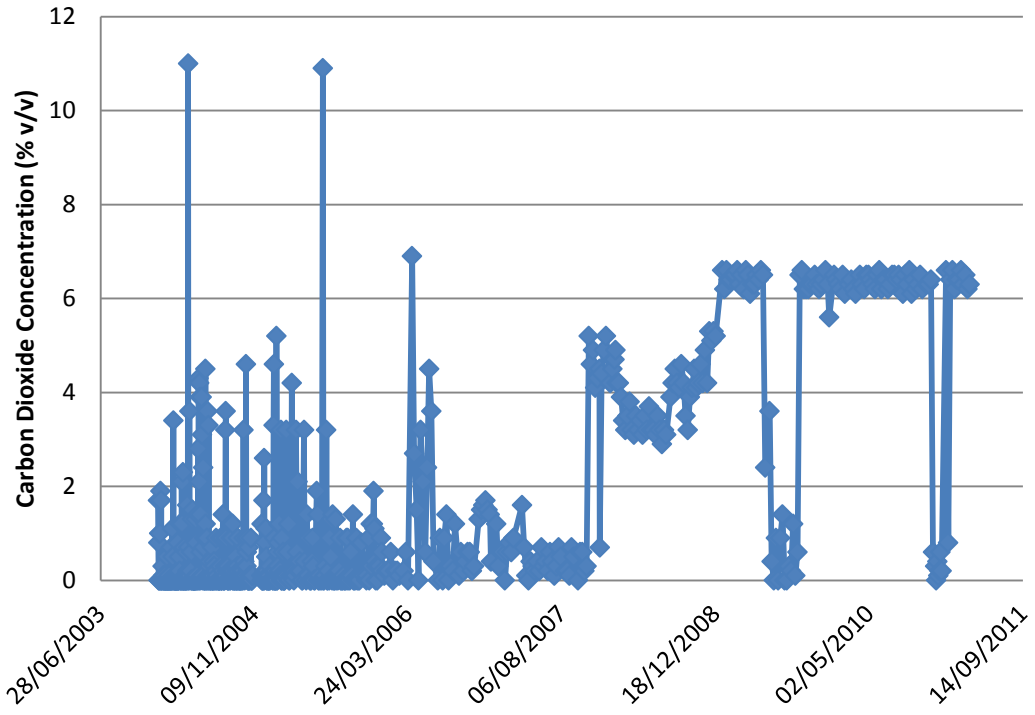
STBH 13



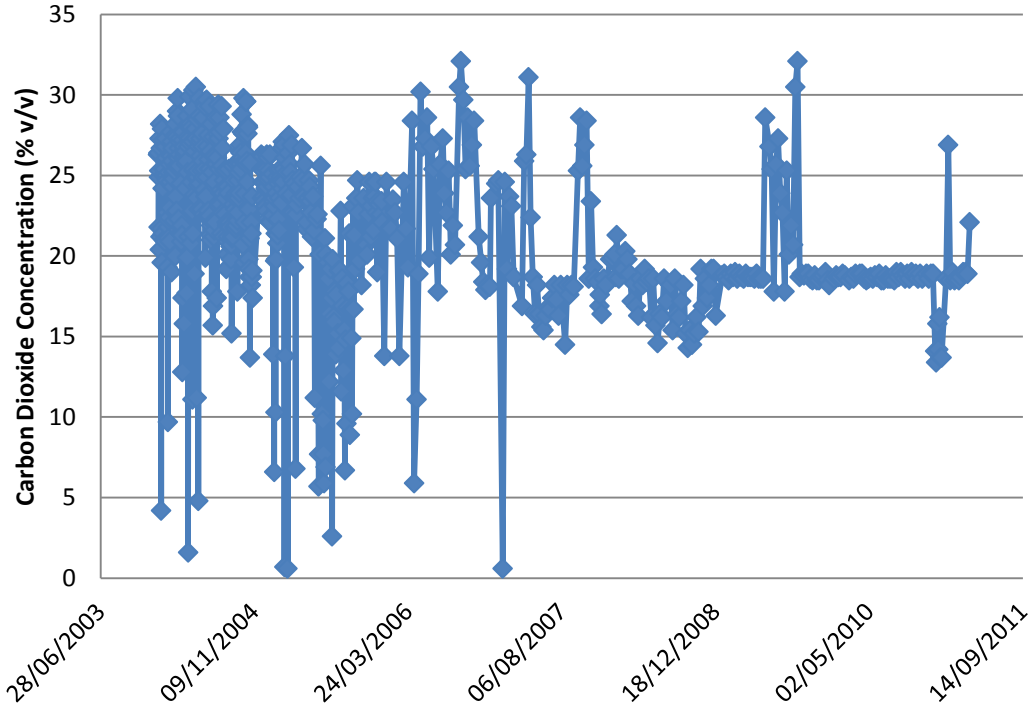
STBH 15



STBH 16



STBH 22



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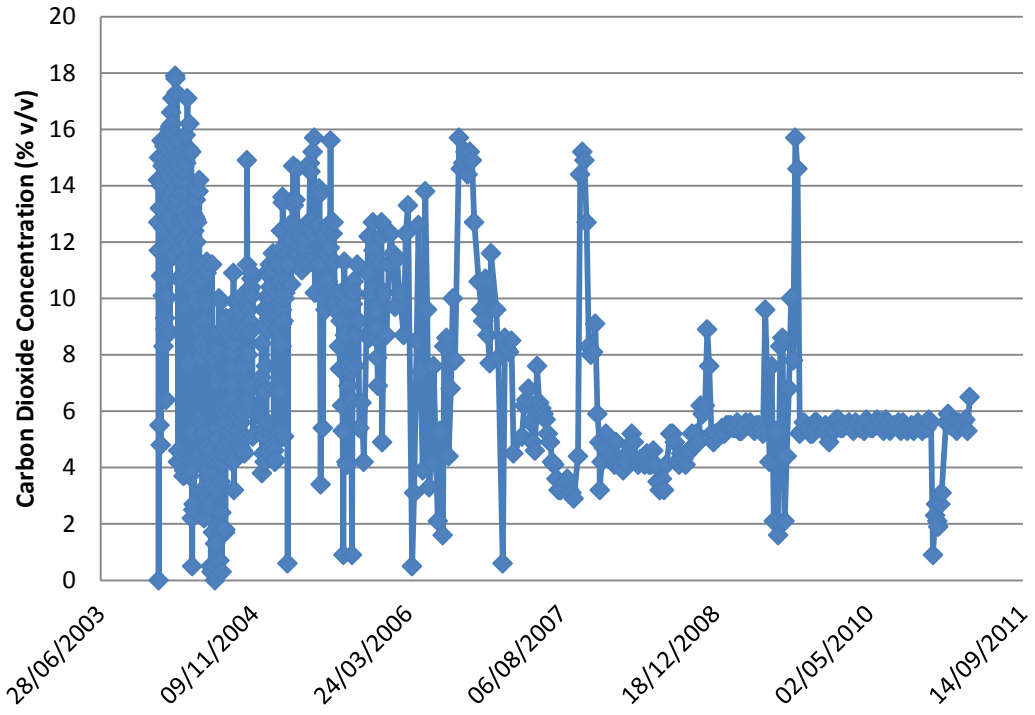
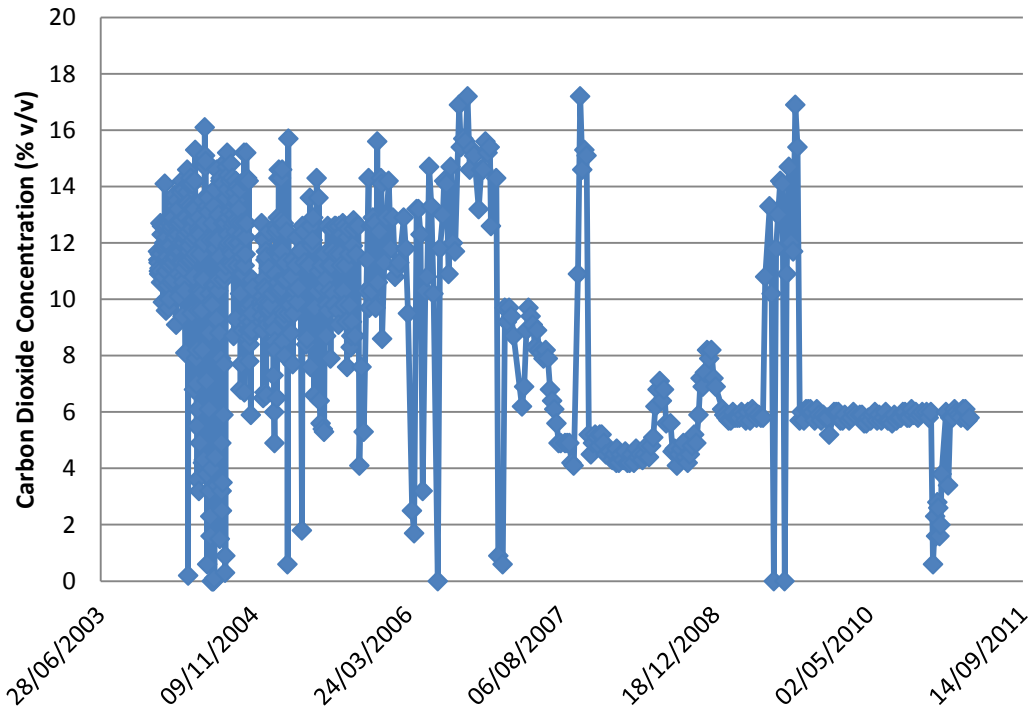
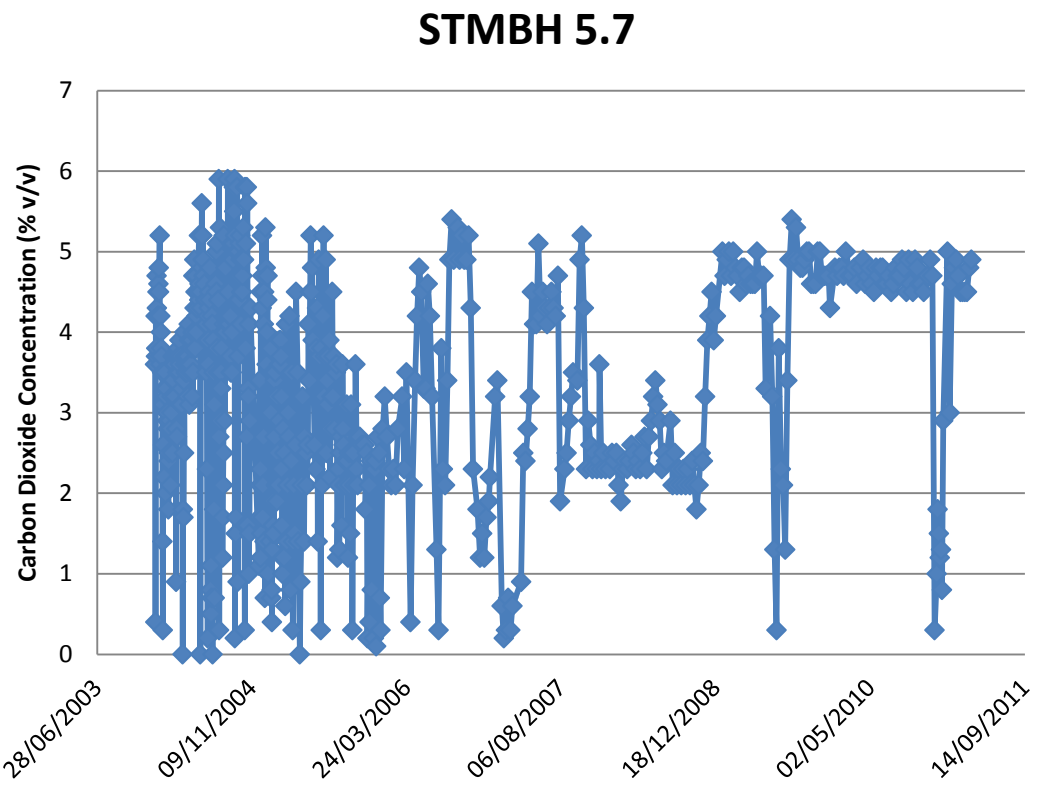


STMBH 5.5




STMBH 5.7
Carbon Dioxide Concentration (% v/v)
7
6
5
4
3
2
1
0
28/06/2003
09/11/2004
24/03/2006
06/08/2007
18/12/2008
02/05/2010
14/09/2011

APPENDIX 4

Contact Details – Critical Plant

CYNGOR Sir y Fflint
Flintshire
COUNTY COUNCIL

WASTE MANAGEMENT SERVICE
STANDARD LANDFILL SITE - **CRITICAL PLANT**

ITEM	SUPPLIER	SERVICE INTERVAL	BREAKDOWN RESPONSE	NOTES	CONTACT DETAILS
GAS FLARE 500 cum/hr	BIOGAS TECHNOLOGY LIMITED CAMBRIDGE	3 MONTHLY	24 HOURS	Serviced by Biogas Quarterly	Mr John James Biogas 01487-831701
GAS BLOWERS 2NR	UNI-FLARE LTD	3 MONTHLY	24 HOURS	Authorised UK Service Agent	Marcus Jones 01676-529118
LEACHATE PUMPS SYSTEM	VIRIDIAN SYSTEMS LIMITED	3 MONTHLY (ONGOING)	48 HRS	Daily inspections in place	Roger Dixon 0151-6398666
AIR COMPRESSOR	ACC LIMITED WIDNES	3 MONTHLY	24 HR ON CALL	Auto pressure loss alarm system in place.	Paul Hodgeson 0151-4249673
GAS ENGINE	FINNING (UK) LTD	MONTHLY	48 HOURS	Checked daily	Donna Golding 01753-497352
MAINS POWER SUPPLY	MANWEB-SCOTTISH POWER	AS REQUIRED	24 HR ON CALL	Emergency response in place	Emergency Response Centre 0845-2722424 or 0151-609-4866
KNOCK OUT POTS	VIRIDIAN SYSTEMS	3 MONTHLY	48 HOURS	Daily inspections in place	Roger Dixon 0151-6398666

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Appendix 5

Caulmert Limited

Engineering, Environmental & Planning
Consultancy Services

Standard Landfill Site

Flintshire County Council Waste Management Services

Groundwater Management and Monitoring Plan

Prepared by:

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Document Reference: 1629.10.FCC.JDM.ÅKS.A0

July 2013

Caulmert
Engineering, Environmental and Planning

APPROVAL RECORD

Site: **Standard Landfill Site**

Client: **Flintshire County Council Waste Management Services**

Document Title: **Groundwater Management and Monitoring Plan**

Document Ref: **1629.10.FCC.JDM.ÅKS**

Report Status: **A0**

Project Director: **Åsa Strickland**

Project Manager: **Jim McClymont**

Caulmert Limited: **InTec, Parc Menai, Bangor, Gwynedd, LL57 4FG**

Tel: **01248 672666**

Author	Jim McClymont	**Date**	30.07.2013
Reviewer	Åsa Strickland	**Date**	31.07.2013
Approved	Åsa Strickland	**Date**	01.08.2013

DISCLAIMER

STANDARD LANDFILL SITE

GROUNDWATER MANAGEMENT AND MONITORING PLAN

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APPENDICES

1.0 INTRODUCTION

1.1 Background

1.1.1 Flintshire County Council Waste Management Services (FCC) appointed Caulmert Limited (Caulmert) to revise and update the current Groundwater Management and Monitoring Plan for Standard Landfill Site to reflect current site conditions. The previous Plan was submitted as part of the Landfill Closure Report submitted by AD Waste Ltd in November 2007[1].

1.1.2 In EPR Compliance Assessment Report ID: RDR/130304/37073, dated the 4th of April 2013, Natural Resources Wales (NRW) requested that *'the groundwater management and monitoring plan and conceptual model should be updated and the interim compliance levels reviewed as it is now over two years since the additional and replacement groundwater monitoring boreholes were installed in June 2010'.*

1.1.3 This document has been prepared in order to outline the management and monitoring of groundwater at the site during the aftercare phase. It includes a monitoring plan and contingency action plans with reference to Environment Agency Landfill Technical Guidance Note, Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water[2].

1.1.4 A full groundwater conceptual model for Standard Landfill Site was submitted by TerraConsult in April 2009[3], this was updated by Caulmert in June 2013[4].

[1] AD Waste Ltd. November 2007. Closure Report, Standard Landfill Site, WML 37073.
[2] Environment Agency. 2004. LFTGN 02. Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water.
[3] Terra Consult. April 2009. Groundwater Conceptual Model. Standard Landfill Site. AD Waste Limited.
[4] Caulmert Ltd. May 2013. Standard Landfill Site - Update to Groundwater Conceptual Model, 1629.11.FCC.JDM.ÅKS.A0.

2.0 GROUNDWATER MANAGEMENT PLAN

2.1 Management Structure

2.1.1 The responsibilities for the delivery of the groundwater management plan for Standard Landfill Site lie with the Environment and Energy Manager, and the Environmental Management Coordinator.

2.1.2 The role of the Environment and Energy Manger is to maintain contact with the relevant NRW officer and to schedule the relevant site works and report production.

2.1.3 The role of the Environmental Management Coordinator is to schedule and conduct the site monitoring exercises, and report exceedances of site trigger levels to the relevant officer.

2.2 Groundwater Infrastructure

2.2.1 The groundwater monitoring infrastructure at Standard Landfill Site consists of 7 dedicated groundwater monitoring boreholes – GW1, GW2, GW3, GW4R, GW5, GW6 and GW7.

2.2.2 GW1, GW2, GW3, GW4, GW5 and GW6 were drilled around the landfill in April 1991 and a further two boreholes (GW4R and GW7) drilled in June 2010[5]. The geological and borehole construction information is summarised in the table below.

Table 1: Borehole Details

Borehole	Total Depth (mbgl)	Ground level (mAOD)	Lithology	Well information
BHGW1	53	123.82	0.0 - 2.8 mbgl: Made Ground (shale and sand). 2.8 - 3.5 mbgl: clay (Boulder Clay). 3.5 - 10 mbgl: mudstone and coal. 10 - 16.7 mbgl: sandstone. 16.7 - 19.9 mbgl: mudstone and coal. 19.9 - 52.5 mbgl: sandstone.	Bentonite seal 0.5 - 1.5 mbgl. Solid HDPE 100 mm diameter casing to 10 mbgl. Slotted screen with gravel filter to 52.5 mbgl.
BHGW2	59.5	117.07	0.0 - 1.5 mbgl: Made Ground (brick rubble, ash, soil). 1.5 - 4.1 mbgl: clay (Boulder Clay). 4.1 - 46.5 mbgl: mudstone and coal. 46.5 -59.5 mbgl: sandstone.	Bentonite seal 0.5 - 1.5 mbgl. Solid HDPE 100 mm diameter casing to 4.5 mbgl. Slotted screen with gravel filter to 59.5 mbgl.

[5] TerraConsult. July 2010. Validation Report – Groundwater Monitoring Wells. Standard Landfill Site, Buckley, Flintshire.

Borehole	Total Depth (mbgl)	Ground level (mAOD)	Lithology	Well information
BHGW3	56.5	113.42	0.0 -0.4 mbgl: Made Ground (ash and shale). 0.4 - 2.0 mbgl: clay (Boulder Clay). 2.0 - 13.6 mbgl: mudstone and coal. 13.6 - 30.1 mbgl: sandstone and coal. 30.1 - 45.8 mbgl: mudstone and coal. 45.8 - 54.7 mbgl: sandstone. 54.7 - 56.5 mbgl: coal.	Bentonite seal 0.5 - 1.5 mbgl. Solid HDPE 100 mm diameter casing to 3 mbgl. Slotted screen with gravel filter to 56.5 mbgl.
BHGW4	57	130.93	0.0 - 1.2 mbgl: Made Ground (clay and shale). 1.2 - 1.6 mbgl: clay (Boulder Clay). 1.6 - 17.8 mbgl: mudstone and coal. 17.8 - 35.5 mbgl: sandstone. 35.5 - 56.5 mbgl: mudstone and coal.	Bentonite seal 0.5-1.5 mbgl. Solid HDPE 100 mm diameter casing to 3 mbgl. Slotted screen with gravel filter to 56.5 mbgl.
BHGW4R	53	131.00	0.0 – 1.0 mbgl: Made Ground (clay and shale). 1.0 – 1.7 mbgl: clay (Boulder Clay). 1.7 – 15.0 mbgl: mudstone and coal. 15.0 – 19.0 mbgl: sandstone. 19.0 – 25.5 mbgl: mudstone and coal. 25.5 – 26.8 mbgl: sandstone. 26.8 – 30.0 mbgl: mudstone. 30.0 – 32.0 mbgl: sandstone. 32.0 – 43.2 mbgl: mudstone. 43.2 – 45.0 mbgl: siltstone. 45.0 – 47.0 mbgl: mudstone. 47.0 – 53.0 mbgl: sandstone.	Bentonite seal 0.2-3.0 mbgl. Solid HDPE 90 mm diameter casing to 4 mbgl. Slotted screen with gravel filter to 53.0 mbgl.
BHGW5	34	139.47	0.0 - 1.4 mbgl: Made Ground (colliery waste). 1.4 - 7.3 mbgl: clayey-sand (Boulder Clay). 7.3 - 9.7 mbgl: mudstone and coal. 9.7 - 16.9 mbgl: sandstone. 16.9 - 26.6 mbgl: mudstone and coal. 26.6 - 34 mbgl: sandstone.	Bentonite seal 0.5-1.5 mbgl. Solid HDPE 100 mm diameter casing to 6.6 mbgl. Slotted screen with gravel filter to 34 mbgl.

Borehole	Total Depth (mbgl)	Ground level (mAOD)	Lithology	Well information
BHGW6	49	123.06	-	No information available.
BHGW7	71	142.00	0.0 – 1.3 mbgl: Made Ground (asphalt and sub-base) 1.3 – 6.6 mbgl: Made Ground (sand with ash, brick and slag) 6.6 – 9.5 mbgl: mudstone. 9.5 – 16.0 mbgl: sandstone. 16.0 – 66.0 mbgl: mudstone and coal. 66.0 – 71.0 mbgl: sandstone.	Bentonite seal 0.1-8.0 mbgl. Solid HDPE 90 mm diameter casing to 9 mbgl. Slotted screen with gravel filter to 71 mbgl.

2.3 Groundwater Infrastructure Maintenance Procedures

2.3.1 All operational, inspection and maintenance procedures will be carried out in accordance with the Groundwater Monitoring Plan, as outlined in Section 3 of this report.

2.3.2 The 'depth to base' of each groundwater monitoring point will be recorded annually, to check for evidence of silting or blockage. Problems with gaining access to monitoring points and/or monitoring equipment will also be noted.

3.0 GROUNDWATER MONITORING PLAN

3.1 Monitoring and Sampling Plan

3.1.1 Groundwater sampling and level monitoring will be undertaken at all locations in accordance with the monitoring regime below.

3.2 Monitoring Regime

3.2.1 Groundwater levels shall be monitored on a monthly basis while groundwater quality will be monitored quarterly as detailed in Table 2 below. All monitoring shall be carried out in accordance with Environment Agency document LFTGN 02[6].

Table 2: Groundwater Monitoring Schedule

Test type and monitoring points	Total	Frequency	Suite	Unit	Compliance Limit
Groundwater Levels					
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Monthly	Dip to liquid	mBGL	N/A
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Annually	Dip to base	mBGL	N/A
Groundwater Quality					
GW1, GW2, GW3, GW4R, GW5, GW6 and GW7	7	Quarterly	NH_4-N	mg/l	6.4 mg/l*
			Cl^-, As, Cd, Cu, Fe, Pb, Mg, Hg, Ni, Zn, Alkalinity ($CaCO_3$), K, Na, Nitrate, Nitrite, SO_4, TON, total phenols, total cyanide, BOD and COD		N/A
			pH	-	N/A
		Annually	Hazardous Substances Suite	µg/l	N/A

*Applies to GW3, GW4R, GW6 and GW7 only

[6] Environment Agency. 2002. LFTGN02 Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water.

3.3 Reporting of Results

3.3.1 All monitoring data will be stored on the site operator's database.

3.3.2 Upon receipt, all monitoring data will be checked, and abnormal results investigated. If necessary, re-testing will be arranged.

3.3.3 Quarterly and annual reviews of all monitoring data will be carried out, where data will be presented, interpreted and reviewed in accordance with Section 10 in LFTGN 02.

3.4 Sampling Equipment

3.4.1 The site operator will provide appropriate instrumentation for use in the environmental monitoring of the site.

3.4.2 The instruments will be serviced in accordance with the manufacturer's recommendations and a calibration certificates will be made available on request of the Environment Agency.

3.5 Sampling Methodology

3.5.1 Wherever possible, the groundwater samples should be collected over a single day, and on the same day as leachate and surface water samples.

3.5.2 Samples of groundwater collected should be submitted for analysis to a laboratory accredited by UKAS or similar approved. The laboratory should be able to demonstrate an acceptable quality of current results through participation in an independent proficiency check-scheme.

3.5.3 Analytical requirements and sampling frequencies are shown in Section 3.2 of this plan. It should be noted that the programme may be subject to change and that any changes are to be reported to the Environment Agency in writing.

3.5.4 All sampling procedures will be in line with the recommendations of Section 9.0 in LFTGN02. The procedures contained in Appendix 1 of this document will be agreed with NRW and will be taken as the minimum standard.

3.6 Quality Control

3.6.1 Appropriate quality assurance and quality control procedure should be followed to ensure the validity of the collected data. Such measure should include:

i. Separate sampling equipment dedicated to groundwater sampling i.e. bailers;
ii. Rinsing of groundwater level monitoring equipment with clean water between monitoring points;
iii. Filling of sample bottles to the brim to exclude air where appropriate;
iv. Transport of samples to the laboratory (in cool boxes) within 24 hours of collection; and
v. Chain of custody documentation for samples.

3.7 Installation Maintenance

3.7.1 Maintenance of sampling installations shall be the responsibility of the site operator.

3.7.2 Any lost or damaged sampling equipment shall be repaired or replaced immediately from when the deficiency becomes known.

3.7.3 At all times installations shall be clearly visible. Vegetation should be cut as necessary from around both flush and raised headworks.

3.7.4 All records of any maintenance or repairs to the groundwater monitoring infrastructure are logged in a log book. The fault, repair/replacement and person/s carrying out the works are recorded. It includes any routine repairs or replacements the infrastructure requires. The records are stored by the operator on site and made available for inspection on demand.

4.0 CONTINGENCY ACTIONS

4.1 Trigger Level Exceedance

4.1.1 If ammoniacal nitrogen concentration exceeded the compliance limit, as shown in Table 2, the following actions should be taken[7]:

Action		Response Time
a)	Advise NRW	One month
b)	Increase survey frequency to monthly	One month
c)	Undertaken site investigation work in cases of uncertainty	Six month
d)	Report to NRW on re-appraisal of risks and options for corrective measures	12 months

[7] Environment Agency. Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water. Table 7.3.

APPENDIX 1

Groundwater Sampling Protocol

GROUNDWATER SAMPLING PROTOCOL

Equipment and Maintenance

Any equipment used in the monitoring of groundwater will be serviced and maintained in accordance with the manufacturers recommendations.

A log of maintenance will be kept by the site operator.

Groundwater Sampling Protocol:

Pre-checks

i. Check all equipment is operational, e.g. check batteries, probes, meters etc. are in working order;

ii. Check calibrate equipment, e.g. dip meters, pH, temperature, conductivity, Eh and DO probes;

iii. Clean and decontaminate all equipment;

iv. Check the requirements of the monitoring visit how many samples are to be taken and analysis required;

v. Check which bottles are required and that they are of the correct type;

vi. Ensure you have the correct Personal Protective Equipment, as per risk assessments.

On Site

i. Record in the site diary sampling equipment and method used, name of technician and on-site weather conditions;

ii. During the course of the monitoring visit a visual inspection of the site and its surroundings should be made.

At the borehole

i. Unlock and/or remove protective cover;

ii. Record any damage to the condition of the borehole and monitoring point;

iii. Dip the groundwater from cover level and record the depth to the top of the groundwater and the base of the borehole;

iv. Calculate and record borehole water volume: length of water column in borehole (L) = depth –dip. Borehole volume = $\prod d^2.L/4$ (using consistent units);

v. Calculate and record purge volume (if required), e.g. 3 borehole volumes;

vi. Layout and assemble all purging, field measurement and sampling equipment;

vii. Measure and record field measurements immediately before or at the time of sampling, e.g. temperature, pH, EC, DO;

viii. Take samples that do not require field preservation – fill the sample bottle directly from the discharge tubing wherever possible. Rinse the bottles with sample water and fill to the top, leaving no air space. Check sample label, adding an necessary additional information;

ix. Take samples that require field preservation – do not rinse bottles and only fill to level in bottle as instructed by the laboratory;

x. Withdraw non-dedicated sampling equipment from borehole, taking care not to damage equipment or borehole;

xi. Replace protective covers on monitoring points and secure;

xii. Dispose of contaminated purge water.

At the site office

i. Clean the outer surface of all sample containers with paper towels and check that all sample bottles are labelled correctly and securely. Seal container as appropriate;

ii. Place all samples in storage and transport containers, protecting containers from breakage as appropriate;

iii. Prepare chain-of-custody documents and seal one copy inside sample transport container;

iv. Hand over sample to courier or transport directly to laboratory – all samples should be delivered to a laboratory within a stated time period from sampling (ideally on the same day as monitoring.

Reporting Results

i. Any problems recorded as part of the visual inspection during the sampling procedure will be recorded in the site diary and the Environment and Energy Manger will be informed.

ii. Once the laboratory analysis reports are received, import data into the site operator's database, check for any breaches in trigger levels and inform the Environment and Energy Manger. A report should be printed and distributed to Natural Resources Wales within one month of receipt of the lab test results and a copy kept on the site file.

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