

CEMEX UK Materials Limited
Whitehall Landfill
Permit number: MP3036SS
Variation number: LP3630MR

Annual environmental monitoring report for 2018

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1 Introduction

The Environmental Permit for Whitehall Landfill site, no. MP3036SS, issued by the Environment Agency on 17 March 2006, specifies under condition 4.2.1 that:

“A report or reports on the performance of the activities over the previous year shall be submitted to the Agency by 31 January (or other date agreed in writing by the Agency) each year. The report(s) shall include as a minimum:

- (a) a review of the results of the monitoring and assessment carried out in accordance with this permit against the relevant assumptions, parameters and results in the risk assessments submitted in relation to this installation and any agreed amendments thereto;*
- (b) where the operator’s management system encompasses annual improvement targets, a summary report of the previous year’s progress against such targets;*
- (c) the annual production/treatment set you in schedule 5 table S5.2*
- (d) details of any contamination or decontamination of the site which has occurred*
- (e) the topographical surveys required by condition 3.6.3 other than those submitted as part of a CQA validation report;*
- (f) the volumetric difference (reported in cubic metres) between the most recent topographical survey and the previous annual topographical survey i.e. the additional volume of the landfill void that is occupied by waste;*
- (g) an assessment of the settlement behaviour of the landfill body based on the difference between the most recent topographical survey and previous annual topographical survey for the areas of the landfill which did not receive waste between the surveys;*
- (h) a calculation of the remaining capacity (reported in cubic metres) derived from the pre-settlement contours and the most recent topographical survey;*
- (i) a summary of the WAC compliance testing undertaken in the period”*

This report is presented in compliance with this condition.

The installation is a landfill site and associated infrastructure, for disposal of inert waste. The Site covers an area of 5.2 ha and lies in a closed limestone quarry to the northwest of Wenvoe, approximately six miles southwest of Cardiff City Centre, South Glamorgan, at NGR 311700 173450.

The Site is surrounded by fields and woodland to the north and woodland to the east (Figure 1). To the west of the site are fields crossed by footpaths and containing a small pond. The southern part of the site is mostly bounded by fields and a track, with woodland towards the eastern part. The south eastern tip of the site is bounded by the houses and gardens along Walston Road in Walston which is at the north western edge of Wenvoe.

2 Site History

The landfill occupies a limestone quarry that was operational from around 1930 until 1976. After cessation of operations the Site lay dormant for 20 years. In 1984 a planning application for disposal of inert waste was approved. Following this, in 1996, a Waste Management Licence was granted (by the WRA, the Vale of Glamorgan Borough Council at the time) and landfill operations at the site began.

Waste was first accepted at Whitehall Landfill in November 1998. The Site formally operated under Waste Management Licence Number WM130189. Under the WML, the site was licensed to accept solid inert wastes including soils (top soil, sub-soil and overburden), brickwork, stone, concrete, sand (excluding foundry sand), cement, plastics, glass and fired pottery/ceramics. Certain other materials could also be accepted into the landfill provided that together they made up no more than 1% by volume of any one load. These included plaster, wood, wood products and cardboard and paper products.

The principal waste streams which arrived at Whitehall Quarry were all of construction and demolition waste, originating from various districts within Wales.

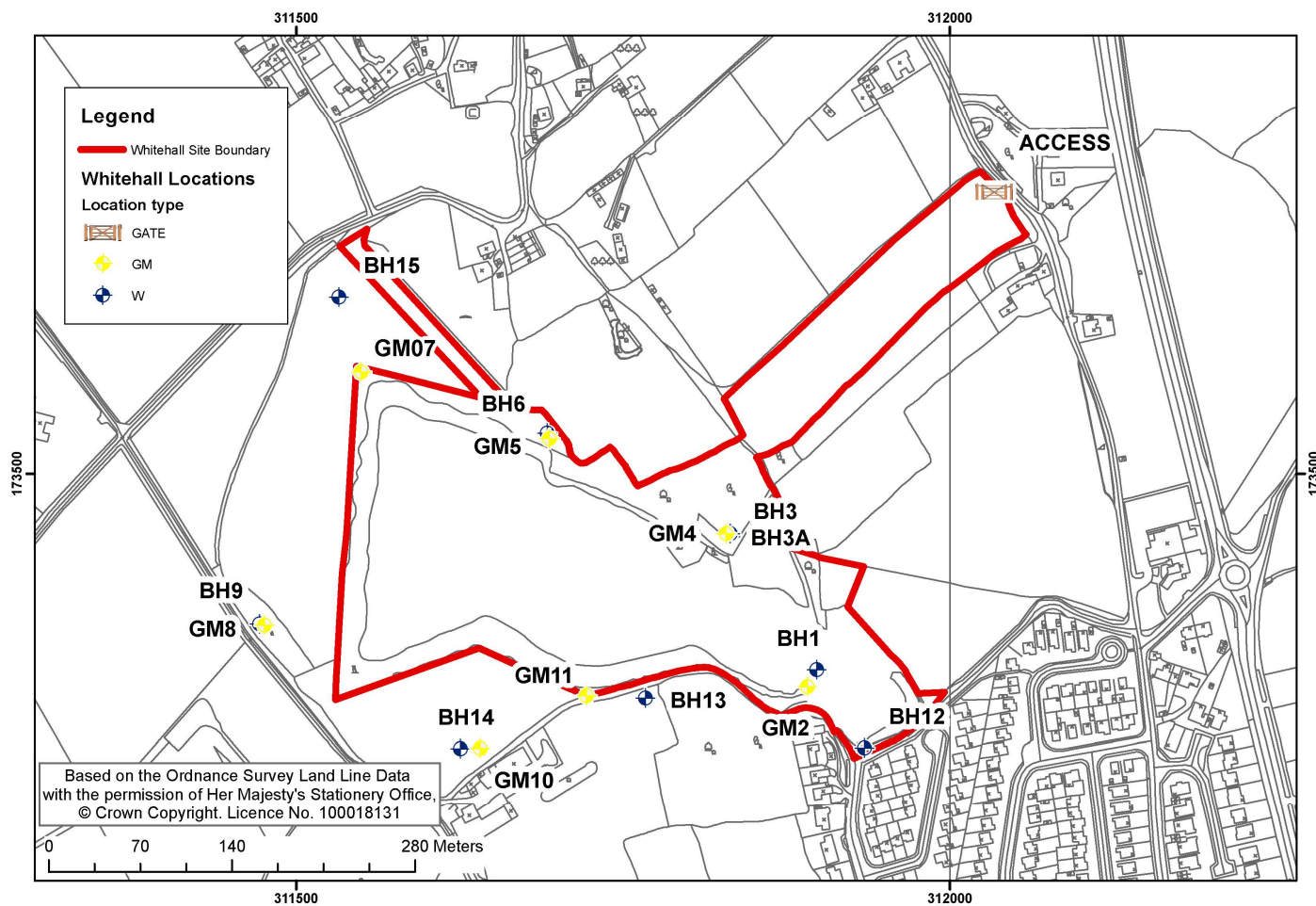
There are three closed landfills situated to the north, up gradient of Whitehall Quarry. The most northerly of these, Greenwood Quarry, located approximately 500 m from Whitehall Quarry (Drawing ESID 2, ESI/Arup (2005)), was licensed to receive inert and semi-inert material (Wildgust, 1998. Lafferty, 1998). Operations ceased in 1988. Greenwood Old Quarry lies immediately south of this and was licensed to accept solid non-toxic wastes although Wildgust (1998) and Lafferty (1998) suggest that material outside this classification was also accepted.

The most southerly of these sites, Blue Pool, located approximately 130 m from Whitehall Quarry (Drawing ESID 2, ESI/Arup (2005)), accepted solid non-toxic wastes and asbestos. Again Wildgust (1998) and Lafferty (1998) suggest other materials were disposed of at this site.

The Site covers an area of 5.2 ha and lies in a closed limestone quarry to the northwest of Wenvoe, approximately six miles southwest of Cardiff City Centre, South Glamorgan, at NGR 311700 173450. It is permitted to accept inert waste, however it stopped accepting waste at the end of October 2018. The site is surrounded by fields and woodland to the north and woodland to the east (Figure 1). To the west of the Site are fields crossed by footpaths and containing a small pond. The southern part of the site is mostly bounded by fields and a track, with woodland towards the eastern part. The south eastern tip of the Site is bounded by the houses and gardens along Wallston Road in Wallston which is at the north western edge of Wenvoe.

Whitehall landfill is certified to the environmental management standard ISO 14001:2015.

Figure 1 Site location plan



3 Review of Monitoring Data

Schedule 4 of the site Permit specifies that monitoring of landfill gas and groundwater level and quality is required to assess any potential impact of the landfill on the surrounding environment. The following sections review the data collected from January to the end of the calendar year in December 2018. The locations of the monitoring points are shown on Figure 1.

3.1 Landfill Gas Monitoring

Landfill gas has been monitored for selected parameters in seven perimeter gas monitoring boreholes on a monthly frequency in accordance with the requirements specified in the variation notice. The location of these boreholes is shown on Figure 1.

Appendix A presents all gas monitoring data collected at these locations during 2018.

One of the stipulated gas monitoring locations, GM7, was lost in 2007. It was replaced by BH15 and gas monitoring had been undertaken at this location (with some interruptions for accessibility issues) since December 2007 until March 2017 when GM7 was located and monitoring resumed.

Compliance limits for stable methane and carbon dioxide of 1 % v/v and 6 % v/v respectively have been derived to provide threshold criteria and allow quantitative assessment of any potential harmful emissions from the landfill.

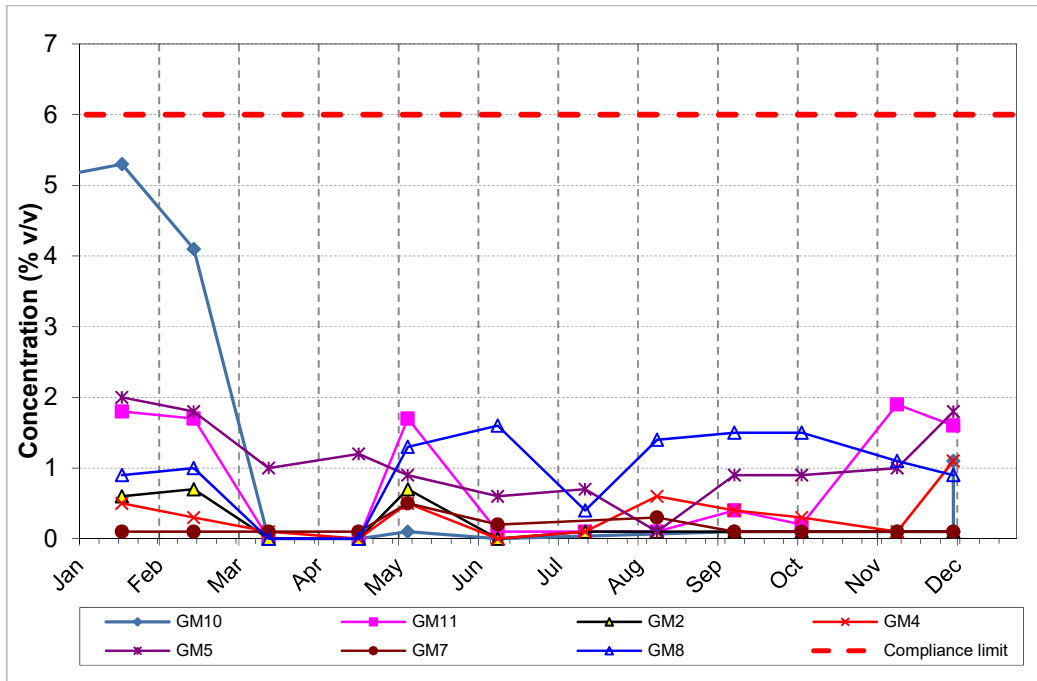
Methane has not been detected throughout the monitoring period in 2018, except in GM2, GM4 and GM8 in May, June and July when it was detected at 0.1 % v/v. There have been no exceedances of the compliance limit.

Table 1 Compliance limits for landfill gas monitoring in perimeter boreholes

Compliance Limit % v/v		
Monitoring Locations	Carbon Dioxide	Methane
GM2	6	1
GM4	6	1
GM5	6	1
GM7	6	1
GM8	6	1
CM10	6	1
CM11	6	1

Stable carbon dioxide concentrations between January and December 2018 are compared to the 6% v/v compliance limit at the required gas monitoring locations in Figure 2 below.

Figure 2 Stable carbon dioxide concentrations in 2018

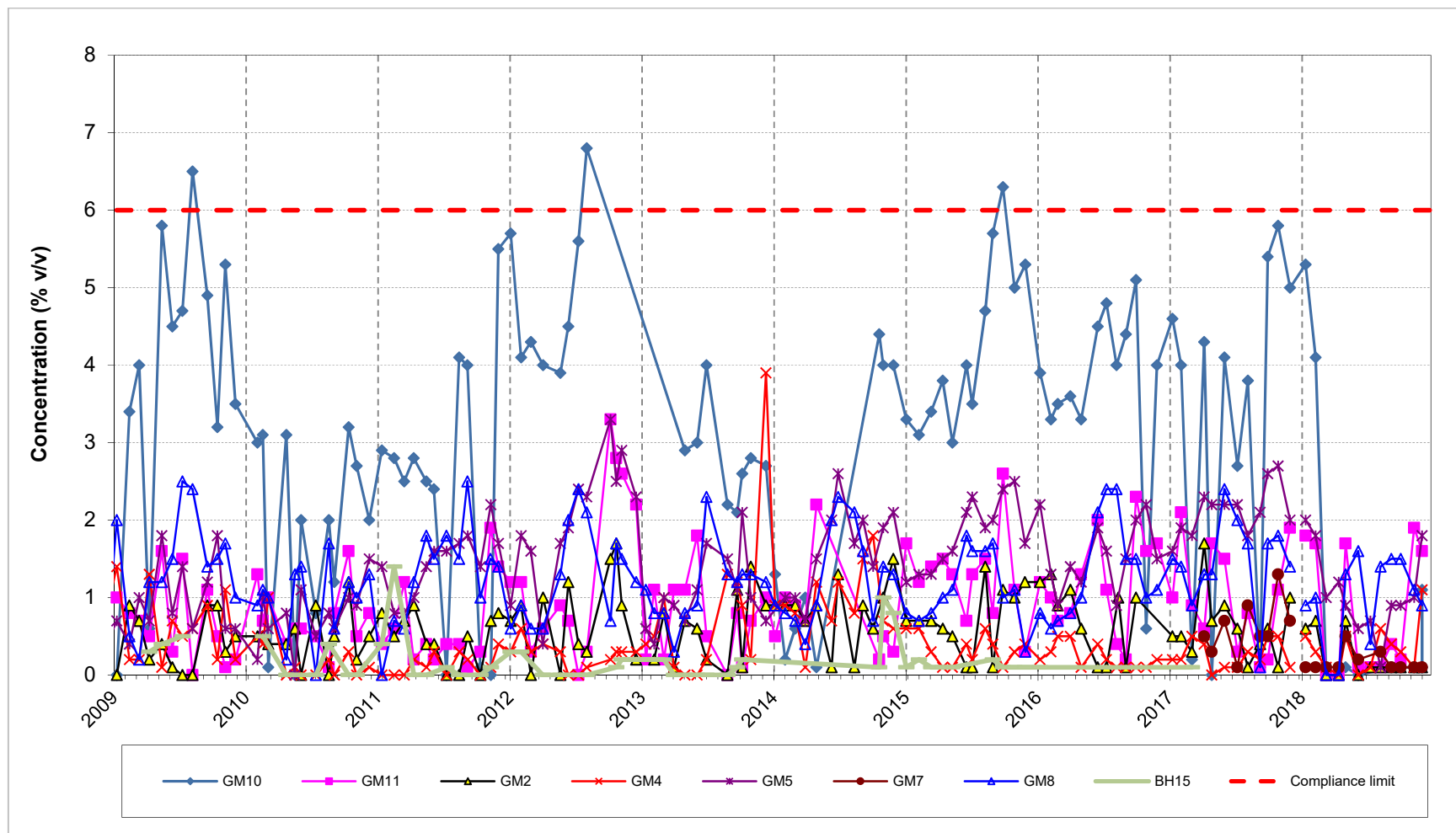


The carbon dioxide compliance limit was not exceeded on any occasion during 2018; however, GM10 came close to the limit in January and February. The majority of monitoring locations showed concentrations below 2 % v/v. Historically carbon dioxide concentrations have always been highest in GM10 and this continued to be the case at the start of 2018 with a maximum reading of 5.3 % v/v before declining to 0.1 % v/v.

As with previous years, there are no apparent short-term trends in the data and concentrations are variable over the year at all monitoring points. Variations tend to correlate from one borehole to another and are presumably related to variations in barometric pressure.

Historical stable carbon dioxide concentrations from early 2007 onwards are presented in Figure 3. The data show that carbon dioxide concentrations were slightly lower in 2018 to those in 2017 but are similar to previous years. However, since March 2018 GM10 has shown significantly lower carbon dioxide concentrations than previous years with concentrations of no greater than 0.1 % v/v.

Figure 3 Historical stable carbon dioxide concentrations



3.2 Groundwater Monitoring

Schedule 4 of the Permit requires groundwater quality to be monitored at four down-gradient site perimeter boreholes, BH1, BH12, BH13 and BH14, which have compliance limits set, as well as at five up-gradient boreholes BH3, BH3A, BH6, BH9 and BH15, which do not have any compliance limits, for the parameters listed in Table S4.4 of the permit (and summarised in Table 2). These locations were sampled on a quarterly and annual frequency for relevant determinands during 2018. The locations of the monitoring boreholes are shown on Figure 1.

Table 2 Groundwater monitoring requirements

Borehole	Parameter	Frequency
BH1, BH3, BH3A, BH6, BH9, BH12, BH13, BH14, BH15	Water level, pH, EC, NH4-N, Cl-, SO4, Alk, TON, TOC, Na, K, Ca, Mg, Fe	Quarterly ¹
	Mn, Cd, Cr, Cu, Ni, Pb, Zn, Naphthalene	Annually

¹ Frequency reduced from monthly to quarterly in mid-2015.

Control levels and compliance limits were updated for selected locations following the 2016 HRA review (ESI, 2016). These changes were agreed with NRW via letter and email dated 15 July 2016.

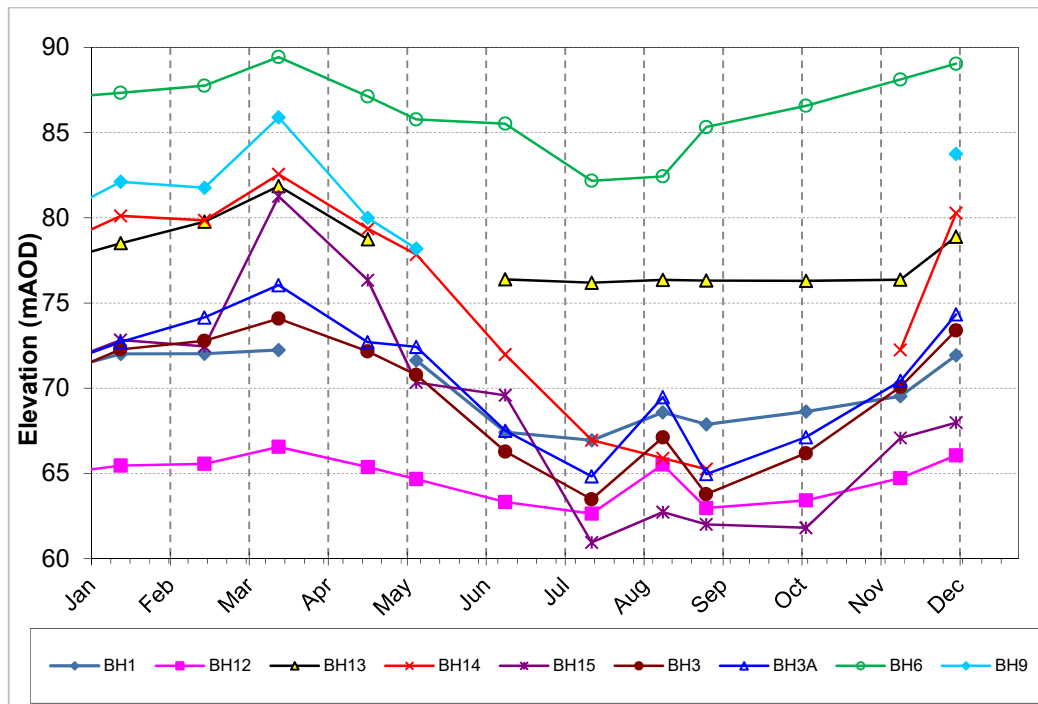
3.2.1 Groundwater Levels

Figure 4 presents the monthly groundwater level data collected during 2018.

There are four boreholes that had periods with no monitoring during 2018, these included BH1, BH13, BH14 and BH9. BH1 was not dipped in April as the cover could not be removed. BH13 was not dipped in May due to topsoil being laid down by the farm and hence unable to be located. BH14 was not dipped in October as the location was inaccessible due to overgrown vegetation. Finally, BH9 was recorded as dry between June and November which is to be expected, as discussed in previous monitoring reports.

In general, groundwater elevations during 2018 showed little change from the previous year (shown in Figure 5) but are most similar to 2013. Water levels showed seasonal trends with peak water levels in March and the lowest levels in July. BH15 recorded the lowest water level since monitoring started at 60.9 mAOD in July due to the very dry summer experienced this year.

Figure 4 Groundwater elevation during 2018

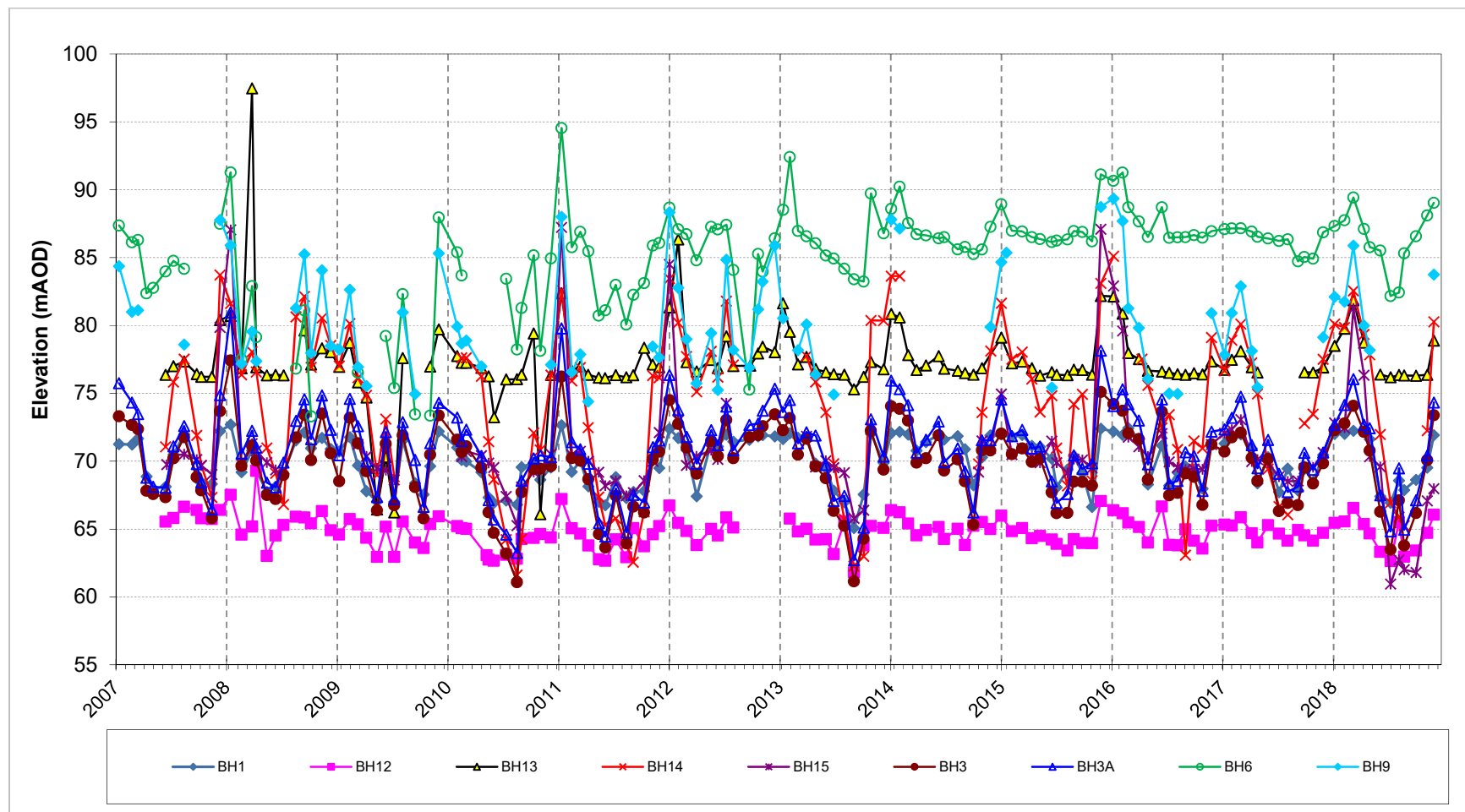


Historical observed water levels for the past 12 years for all monitoring locations are shown in Figure 5. The groundwater levels monitored in BH3 and BH3A exhibit a similar trend to BH1, but with greater variation. The remaining monitoring locations all exhibit similar fluctuation timings, with differing degrees of variation. BH12 and BH13 both show smaller amplitudes than the other wells.

Groundwater levels are generally more variable to the south-west where, historically, the variation in groundwater level is markedly greater in BH14, which continued to be the case during 2018. However, BH15 showed the largest variation in groundwater levels during 2018 with a maximum of 81.3 mAOD and a minimum of 60.9 mAOD (20.4 m).

The range of water levels at the monitoring locations is greater during 2018 compared to previous years, varying between around 5 m and 20 m. It is noted that the June rainfall recorded at the MET Office Cardiff Bute Park weather station (approximately 6.8 km to the north-east of the Site) was the lowest on record at just 8.4 mm, explaining the particularly low summer groundwater levels during 2018. The smallest ranges were recorded in the south-eastern locations BH1, BH12 and BH13. Such variations are common in limestone aquifers that have limited storage potential.

Figure 5 Historical groundwater elevation



3.2.2 Groundwater Quality

Groundwater quality monitoring has been conducted in accordance with conditions specified in Schedule 4 of the PPC Variation Notice (LP3630MR) for stipulated parameters on an approximate monthly or quarterly frequency, and for additional parameters on an annual basis.

The entire data set for 2018 is presented in Appendix C.

Determinands for which compliance limits have been set.

Compliance limits for selected groundwater quality parameters have been derived in order to quantitatively assess landfill performance. A review of defined compliance limits was conducted by CEMEX in 2008 and submitted to the Environment Agency, as the regulating authority at the time, which approved the revised levels. These came into effect in October 2008.

Compliance limits were subsequently revised as part of the 2016 HRA review (ESI, 2016) and these were agreed with NRW in July 2016. Table 3 below details the compliance limits applied to the appropriate groundwater quality determinands at the required locations. There are no compliance limits specified for up-gradient boreholes BH3, BH3A, BH6, BH9 or BH15.

Table 3 Groundwater quality compliance limits

Location	Ammoniacal Nitrogen (mg/l)	Compliance limit			Napthalene (µg/l)
		Chloride (mg/l)	Iron as Fe (µg/l)	Potassium (mg/l)	
BH1	0.39	250	200	27	0.05
BH12				18.6	
BH13				12	
BH14					

A statistical summary of groundwater quality compliance parameters is presented in Table 4. The data for potassium has been split over three rows, as there are separate compliance limits.

During 2018 there was a total of one compliance limit exceedance out of 129 individual analyses carried out. The exceedance was for potassium in BH12 in October 2018 and is displayed in Figure 7.

Table 4 Statistical summary of groundwater compliance parameters in 2018

Determinand	No. of Results	Unit	Min	Max	Mean	95 th Percentile	# > LOD	% > LOD	Limits		
									No. Exceeding	% Exceeding	Action Level
Compliance parameters											
Ammoniacal Nitrogen as N	29	mg/l	<0.06	0.28	n.d	0.19	4	13.8	0	0	0.39
Chloride	29	mg/l	7.1	98.2	39.8	84.8	29	100	0	0	250
Iron	29	mg/l	<0.12	0.157	n.d	n.d	1	3.45	0	0	0.2
Naphthalene	29	µg/l	<0.01	<0.02	n.d	n.d	0	0	-	-	0.05
Potassium (BH1)	3	mg/l	13.1	16.8	14.63	16.5	3	100	0	0	27
Potassium (BH13, 14)	6	mg/l	0.71	3.56	2.358	3.52	6	100	0	0	12
Potassium (BH12)	4	mg/l	9.39	21.3	14.5	20.6	4	100	1	25	18.6

Figure 6 shows groundwater chloride concentrations in 2018 – the maximum concentration was recorded in BH12 and was less than half the compliance limit, reaching 98.2 mg/l in October. In general, concentrations were in line with the data from previous years.

Figure 6 Groundwater chloride concentrations in 2018

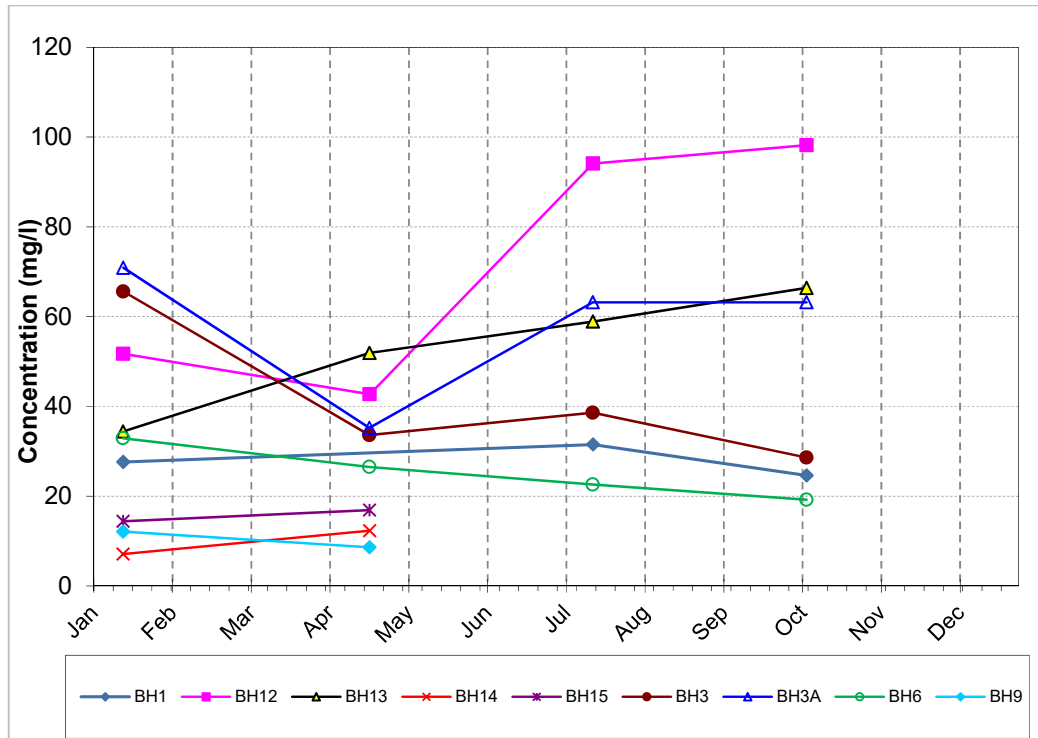
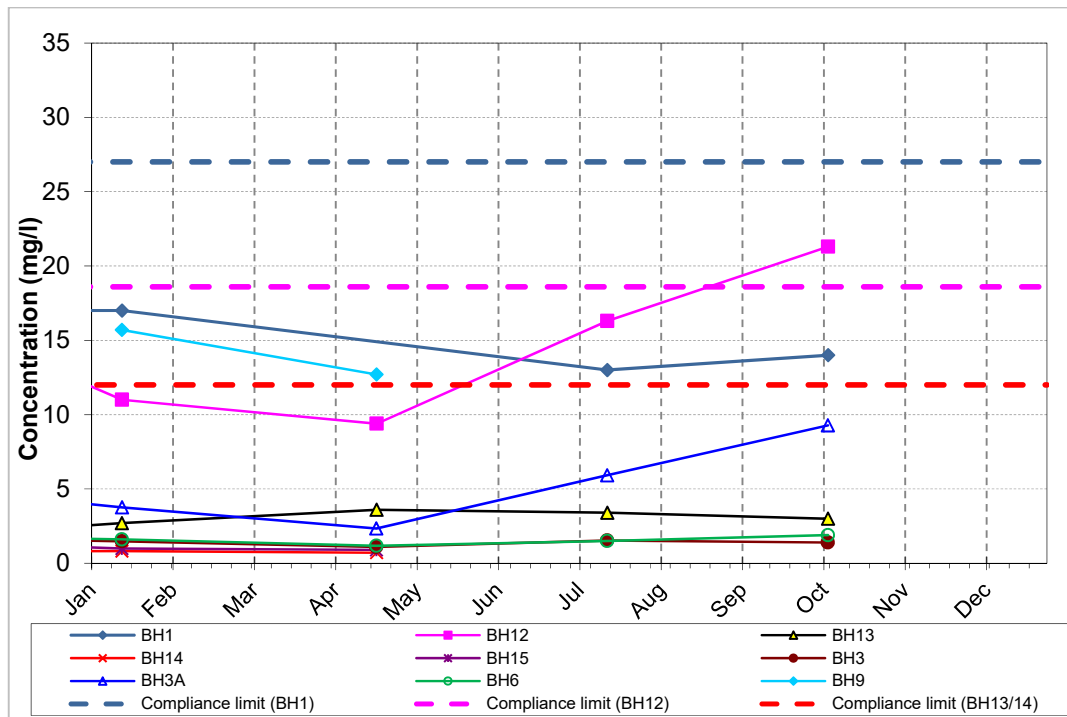


Figure 7 Groundwater potassium concentrations in 2018



Groundwater potassium concentrations during 2018 are presented in Figure 7. As reported in Table 4 there was one exceedance of the compliance limit at BH12 in October at 21.3 mg/l compared to the 18.6 mg/l limit. An increase was recorded from April with the compliance limit then being exceeded in October.

CEMEX (2016) suggested that a plume containing potassium had originated from up hydraulic gradient of the Site and is currently passing through it. Historical potassium concentrations in BH9 (up hydraulic gradient) were higher (Figure 8) but stabilised around 15 mg/l from 2013 before the lowest measured concentration was recorded in April 2018 at 12.7 mg/l. Concentrations at BH1 and BH12 (down hydraulic gradient) had been rising and then levelling off, however during 2018 concentrations appeared to decrease in BH1 but increased in BH12 with a peak at 21.3 mg/l in October. This rise may be influenced by the very dry summer when groundwater levels reduced providing less groundwater dilution. This was the third successive increase in concentrations during 2018 – it is noted that concentrations have historically never increased on more than five consecutive occasions.

Routine sampling in BH9 was not performed between June – November 2018 due to the borehole being dry. This issue was discussed previously in CEMEX (2016).

Based on the most recent data set, it is now considered to be likely that the potassium plume passing beneath the Site has peaked as concentrations are declining in BH9.

In the HRA Review (ESI, 2016) it was noted that the compliance limits were to be reviewed at BH1 and BH12 in order to decide on whether the compliance limits could be lowered. On the basis of the current data, it is recommended that the compliance limits are maintained at their current levels for 2019 and reviewed again in the 2019 annual report.

Iron was only detected once during the year at 157 µg/l. No readings exceeded the compliance limit.

There were no naphthalene exceedances during 2018 (see Table 4).

Other requisite determinants

A statistical summary of general groundwater quality at the site is presented in Table 5. Determinands have been compared to the UK Drinking Water Standards (UK DWS) for reference.

Groundwater quality at the Site is generally good, with exceedances of the UK DWS only recorded during 2018 for sulphate.

The four sulphate exceedances of the UK DWS occurred at BH12 (two results) and BH3A (two results). Historically these locations have always recorded the highest concentrations. Data for 2018 is in line with the historical dataset.

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Table 5 Statistical summary of groundwater quality in 2018

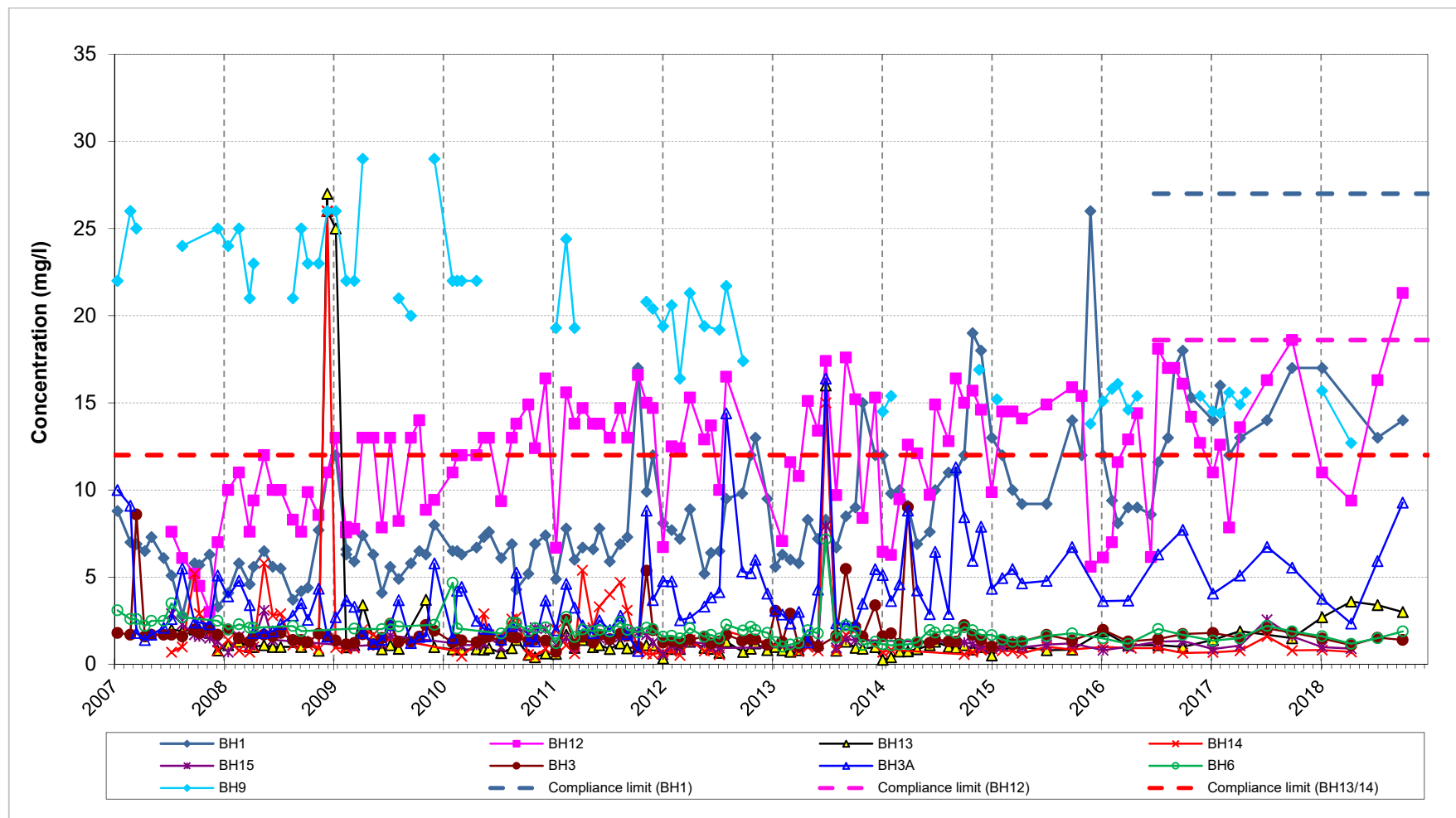
Determinand	No. of Results	Unit	Min	Max	Mean	Standard Deviation	95th Percentile	# > LOD	% > LOD	UKDWS		
										No. Exceeding	% Exceeding	Action Level
Conductivity-Electrical (Field)	29	µS/cm	556	1968	893	340	1576	29	100	-	-	-
Conductivity-Electrical 20deg	29	µS/cm	465	1460	779	252	1322	29	100	-	-	-
pH	29	pH units	7	7.8	7.36	0.19	7.6	29	100	-	-	-
pH (Field)	29	pH units	7.2	8.5	7.68	0.292	8.22	29	100	-	-	-
Major ions												
Alkalinity as CaCO ₃	29	mg/l	193	450	302	76.6	437	29	100	0	0	-
Calcium	29	mg/l	54.2	233	117	44.9	217	29	100	0	0	250
Chloride	29	mg/l	7.1	98.2	39.8	24.5	84.8	29	100	0	0	250
Magnesium	29	mg/l	13.6	45.4	27.3	9.28	43.6	29	100	0	0	50
Potassium	29	mg/l	0.71	21.3	6.18	6.21	16.6	29	100	0	0	-
Sodium	29	mg/l	4.59	58.2	18.7	13.7	49.5	29	100	0	0	200
Sulphate as SO ₄	29	mg/l	<4.4	478	90	138	417	27	93.1	4	13.79	250
Metals												
Cadmium	8	mg/l	<0.0006	<0.0006	n.d.	n.d.	n.d.	0	0	0	0	0.005
Chromium	8	mg/l	<0.002	<0.002	n.d.	n.d.	n.d.	0	0	0	0	0.05
Copper	8	mg/l	<0.009	<0.009	n.d.	n.d.	n.d.	0	0	0	0	2
Iron	29	mg/l	<0.12	0.157	n.d.	n.d.	n.d.	1	3.45	0	0	0.2
Lead	8	mg/l	<0.006	<0.006	n.d.	n.d.	n.d.	0	0	0	0	0.025
Manganese	8	mg/l	0.008	0.018	0.012	0.00321	0.017	8	100	0	0	0.05
Nickel	8	mg/l	<0.003	0.006	0.004	0.00141	0.00565	6	75	0	0	0.02

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Determinand	No. of Results	Unit	Min	Max	Mean	Standard Deviation	95th Percentile	# > LOD	% > LOD	UKDWS		Action Level
										No. Exceeding	% Exceeding	
Zinc	8	mg/l	<0.018	<0.018	n.d.	n.d.	n.d.	0	0	0	0	5
Ammoniacal Nitrogen as N	29	mg/l	<0.06	0.28	n.d.	n.d.	0.19	4	13.8	0	0	0.39
Nitrogen (total oxidised) as N	29	mg/l	<0.7	9.2	1.74	2.14	5.7	14	48.3	0	0	-
Naphthalene	29	mg/l	<1E-05	<2E-05	n.d.	n.d.	n.d.	0	0	0	0	-
TOC (filtered)	29	mg/l	1.1	12.3	4.96	2.9	9.9	29	100	0	0	-

Note: if significant number of results exceed action limit row is coloured as follows: 10 – 25% pale red, 25 – 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Figure 8 Historical groundwater potassium concentrations



4 Other Reporting Requirements

4.1 Production and Treatment

Schedule 5 Table S5.2 requires the operator to report the annual production and treatment of surface water and or groundwater that has been disposed of off-site and or disposed to any effluent treatment plant.

No surface water or groundwater has been taken off site or disposed of to any effluent treatment plant, thus no return is reported for 2018.

4.2 Contamination/Decontamination

There has been no contamination or decontamination of the site within the reporting period.

4.3 Topographical Survey

An up to date topographical survey is included in Appendix D.

4.4 Compliance Testing and Other Details

In 2018 an estimated 49,000 m³ was tipped at the site. The remaining reported capacity is 0 m³ from the site manager.

All waste accepted on the site were from CEMEX Approved List (as detailed in the PPC Application document WHL IPPC Volume 2, Site Operation Plan). Therefore no waste characterisation was required or undertaken.

5 Summary

The review covers the period between January and December 2018 and reviews the landfill gas, groundwater level and groundwater quality dataset at the Site.

The review has shown the following:

- Landfill gas has been monitored on an approximately monthly basis in seven perimeter gas boreholes in accordance with the requirements specified in the variation notice.
- There have been no exceedances of the compliance limit for methane and methane was only detected in May, June and July at 0.1 % v/v at three locations (GM2, GM4 and GM8).
- Carbon dioxide concentrations did not exceed the 6 % v/v compliance limit during the year. The majority of monitoring locations recorded concentrations below 2 % v/v. Concentrations were highest in GM10, as in previous years, with a maximum concentration of 5.3 % v/v in January. However, from March onwards carbon dioxide declined to 0.1 % v/v.
- There were no significant changes in groundwater elevation during 2018. Water levels in March were the highest in the year which were similar values to the previous year. BH15 displayed a great range in water levels throughout the year and recorded the lowest water level since monitoring started at 60.9 mAOD in July.
- Ammoniacal nitrogen was only detected in 4 out of 29 samples during 2018 with no breaches of the compliance limit.
- Chloride concentrations did not exceed the compliance limit in 2018 for any of the monitoring locations. There were no significant changes in the data set from that of previous years with readings still being below half the compliance limit.
- There were no exceedances of the iron compliance limit for the compliance limit locations.
- There was one exceedance of the potassium compliance limit in 2018 at BH12 in October at 21.3 mg/l. Concentrations of potassium in BH9 initially continued to stabilise before declining again in April. Concentrations in BH1 appear to have reached a steady state, with similar concentrations to BH9 following a number of years of rising trends.

6 References

CEMEX, 2016. Whitehall Landfill: Annual Environmental Monitoring Report for 2016.

ESI/Arup, 2005. Whitehall Landfill Conceptual Model, ESID Report.

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Natural Resources Wales [NRW], 2016. Letter from Gwyn Jones to Gillian Ratcliffe, Re: Whitehall Quarry Hydrogeological Risk Assessment, dated 10 June 2016.

Wildgust, N.A., 1998. Hydrogeological Risk Assessment, Whitehall Quarry Landfill, Wenvoe, South Wales. M.Sc. Thesis, Applied Environmental Geology, Dept. of Earth Sciences, University of Cardiff (Unpublished).

Appendix A

Landfill Gas Monitoring Data

Appendix A Table 1 Gas monitoring data for 2018

Location	Date	Baro mb	CH4Peak %v/v	CH4Stable %v/v	CO2Peak %v/v	CO2Stable %v/v	DiffPress mb	O2Stable %v/v
GM10	17/01/2018	1000	0	0	5.3	5.3	0.02	15.1
GM10	14/02/2018	989	0	0	4.1	4.1	0.22	17.8
GM10	15/03/2018	977	0	0	0	0	0.24	21.2
GM10	19/04/2018	1015	0	0	0	0	0.19	21.2
GM10	08/05/2018	999	0.1	0	0.1	0.1	0.38	22.8
GM10	12/06/2018	1009	0.1	0	0.1	0	0.48	21.1
GM10	16/07/2018	Location inaccessible - overgrown						
GM10	13/08/2018	Location inaccessible - overgrown						
GM10	12/09/2018	1014	0.1	0	0.2	0.1	0.02	21.7
GM10	08/10/2018	1010	0	0	0.1	0.1	0.12	21.6
GM10	14/11/2018	1007	0	0	0.1	0.1	-0.14	20.8
GM10	06/12/2018	1002	0	0	0.2	0.1	0.41	21.1
		1002	0	0	1.1	1.1	0.77	20.1
		1006	0	0	0.1	0.1	0.17	21.1
GM11	17/01/2018	1000	0	0	1.8	1.8	0.09	20.6
GM11	14/02/2018	990	0	0	1.7	1.7	0.07	20.6
GM11	15/03/2018	977	0	0	0	0	0.21	21.2
GM11	19/04/2018	1015	0	0	0	0	0.02	21.1
GM11	08/05/2018	1000	0	0	1.7	1.7	10.26	20.8
GM11	12/06/2018		0.7	0	1.1	0.1	0.1	20.9
GM11	16/07/2018	1004	0	0	0.1	0.1	0.26	21.6
GM11	13/08/2018	999	0.1	0	0.2	0.1	0.53	21.6
GM11	12/09/2018	1013	0	0	0.4	0.4	0.09	21.4
GM11	08/10/2018	1009	0	0	0.2	0.2	0.1	21.3
GM11	14/11/2018	1007	0	0	1.9	1.9	2.31	19.3
GM11	06/12/2018	1002	0	0	1.7	1.6	0.96	19.7
GM2	17/01/2018	1005	0	0	0.6	0.6	12.27	20.5
GM2	14/02/2018	994	0	0	0.7	0.7	-0.14	21.6
GM2	15/03/2018	981	0	0	0	0	0.05	21.3
GM2	19/04/2018	1019	0	0	0	0	0.07	21.2
GM2	08/05/2018	1006	0	0	0.7	0.7	0.21	21.7
GM2	12/06/2018	1012	0.1	0.1	0.1	0	0.24	22.1
GM2	16/07/2018	1007	0.1	0.1	0.1	0.1	0.33	21.5
GM2	13/08/2018	1000	0	0	0.1	0.1	-0.02	21.2
GM2	12/09/2018	1019	0	0	0.1	0.1	0.02	21.6
GM2	08/10/2018	1014	0	0	0.1	0.1	0.02	21.4
GM2	14/11/2018	1012	0	0	0.2	0.1	-0.02	21.1
GM2	06/12/2018	1006	0	0	0.1	0.1	0.24	21.1
GM4	17/01/2018	1003	0	0	0.5	0.5	-0.07	20.3
GM4	14/02/2018	993	0	0	0.3	0.3	-0.03	21
GM4	15/03/2018	979	0	0	0.1	0.1	6.21	20.4
GM4	19/04/2018	1016	0	0	0	0	0.02	20.8
GM4	08/05/2018	1001	0	0	0.5	0.5	0.19	20.9
GM4	12/06/2018	1013	0.1	0.1	0.1	0	0.24	22

Location	Date	Baro mb	CH4Peak %v/v	CH4Stable %v/v	CO2Peak %v/v	CO2Stable %v/v	DiffPress mb	O2Stable %v/v
GM4	16/07/2018	1005	0.1	0.1	0.1	0.1	0.12	21.5
GM4	13/08/2018	999	0	0	0.6	0.6	0.09	20.8
GM4	12/09/2018	1015	0.1	0	0.4	0.4	0.03	20.7
GM4	08/10/2018	1011	0	0	0.3	0.3	-0.14	20.9
GM4	14/11/2018	1010	0	0	0.1	0.1	0.29	21.3
GM4	06/12/2018		0	0	1.1	1.1	0.28	20.3
GM5	17/01/2018	999	0	0	2	2	0.1	18.4
GM5	14/02/2018	989	0	0	1.8	1.8	-0.09	19.5
GM5	15/03/2018	976	0	0	1	1	0.12	19.3
GM5	19/04/2018	1014	0	0	1.2	1.2	0.1	18.7
GM5	08/05/2018	998	0	0	0.9	0.9	0.36	20.2
GM5	12/06/2018	1009	0.1	0	1.2	0.6	0.31	21
GM5	16/07/2018	1006	0	0	0.7	0.7	0.28	20.9
GM5	13/08/2018	996	0	0	0.1	0.1	0.29	21.4
GM5	12/09/2018	1012	0	0	0.9	0.9	0.03	20.3
GM5	08/10/2018	1008	0	0	0.9	0.9	-0.03	20.2
GM5	14/11/2018	1006	0	0	1	1	0.07	20.6
GM5	06/12/2018	1001	0	0	1.8	1.8	0.57	18.7
GM7	17/01/2018	1000	0	0	0.1	0.1	0.05	21.2
GM7	14/02/2018	989	0	0	0.2	0.1	0.05	21.8
GM7	15/03/2018	976	0	0	0.1	0.1	0.26	20.2
GM7	19/04/2018	1013	0	0	0.1	0.1	0.19	20.5
GM7	08/05/2018	999	0.1	0	0.5	0.5	0.48	21.6
GM7	12/06/2018	1009	0	0	0.2	0.2	0.34	21.4
GM7	16/07/2018				Flow Fail			
GM7	13/08/2018	998	0	0	0.3	0.3	0.26	21
GM7	12/09/2018	1012	0	0	0.1	0.1	0.1	21.5
GM7	08/10/2018	1009	0	0	0.2	0.1	-0.03	21.3
GM7	14/11/2018	1007	0	0	0.1	0.1	0.09	21.6
GM7	06/12/2018	1001	0	0	0.1	0.1	0.67	21.2
GM8	17/01/2018	1000	0	0	0.9	0.9	0.12	21.2
GM8	14/02/2018	989	0	0	1	1	9.75	21.1
GM8	15/03/2018	976	0	0	0.1	0	0.07	21.3
GM8	19/04/2018	1014	0	0	0	0	0.05	21.5
GM8	08/05/2018	997	0.1	0.1	1.3	1.3	5.62	19.7
GM8	12/06/2018	1010	0.1	0	1.6	1.6	0.53	19.8
GM8	16/07/2018	1004	0.2	0	0.4	0.4	0.19	21.3
GM8	13/08/2018	997	0	0	1.4	1.4	0.36	20.2
GM8	12/09/2018	1011	0	0	1.5	1.5	9.34	20.8
GM8	08/10/2018	1008	0	0	1.5	1.5	-0.02	20.3
GM8	14/11/2018	1007	0	0	1.1	1.1	-0.17	20.1
GM8	06/12/2018	1002	0	0	0.9	0.9	0.34	20.3

Appendix B

Groundwater Level Monitoring Data

Appendix B Table 1 Groundwater level data (mAOD) for 2018

Date	BH1	BH12	BH13	BH14	BH15	BH3	BH3A	BH6	BH9
12/01/2018	72.01	65.46	78.51	80.11	72.83	72.28	72.71	87.33	82.11
14/02/2018	72.02	65.56	79.77	79.85	72.46	72.78	74.15	87.75	81.76
15/03/2018	72.24	66.56	81.86	82.55	81.26	74.08	76.05	89.43	85.89
19/04/2018	¹	65.37	78.74	79.35	76.34	72.16	72.70	87.12	79.99
08/05/2018	71.63	64.67	²	77.85	70.34	70.78	72.43	85.77	78.19
12/06/2018	67.42	63.32	76.39	71.97	69.59	66.28	67.50	85.52	⁴
16/07/2018	66.94	62.64	76.19	66.95	60.95	63.48	64.83	82.17	⁴
13/08/2018	68.58	65.52	76.36	65.89	62.73	67.12	69.48	82.43	⁴
30/08/2018	67.88	62.97	76.32	65.25	62.01	63.78	64.96	85.32	⁴
08/10/2018	68.63	63.42	76.30	³	61.81	66.18	67.13	86.57	⁴
14/11/2018	69.53	64.72	76.37	72.25	67.08	70.08	70.43	88.11	⁴
06/12/2018	71.93	66.06	78.89	80.27	67.98	73.39	74.33	89.04	83.75

¹ – Location damaged

² - Location could not be found.

³ – Location inaccessible – cannot get to the monitoring point.

⁴ – Location dry.

Appendix C

Groundwater Quality Monitoring Data

Appendix C Table 1 Quarterly groundwater quality data for 2018

Location	Date	Alkalinity as CaCO3 mg/l	Ammoniacal Nitrogen as N mg/l	Calcium mg/l	Chloride mg/l	Conductivity- Electrical (Field) µS/cm	Conductivity- Electrical 20deg µS/cm	Iron µg/l	Magnesium mg/l	Naphthalene µg/l	Nitrogen (total oxidised) as N	pH pH units	pH (Field) pH units	Potassium mg/l	Sodium mg/l	Sulphate as SO4 mg/l	TOC (filtered) mg/l
BH1	12/01/2018	223.00	<0.06	89.20	27.60	636.00	607.00	<120	14.00	<0.02	<0.7	7.40	7.50	16.80	11.90	69.20	5.90
BH1	19/04/2018	Damaged headworks prohibiting access															
BH1	16/07/2018	279.00	0.27	122.00	31.50	784.00	729.00	<120	21.00	<0.01	<0.7	7.10	8.00	13.10	16.80	101.00	7.00
BH1	08/10/2018	230.00	<0.06	110.00	24.60	997.00	665.00	<120	17.00	<0.02	9.20	7.10	7.30	14.00	14.90	98.50	9.30
BH12	12/01/2018	367.00	<0.06	178.00	51.70	1099.00	1110.00	<120	32.60	<0.01	2.00	7.40	7.60	11.00	30.90	232.00	5.60
BH12	19/04/2018	274.00	<0.06	155.00	42.70	1082.00	1020.00	<120	29.30	<0.01	2.00	7.30	7.90	9.39	25.40	210.00	5.70
BH12	16/07/2018	318.00	<0.06	233.00	94.10	1631.00	1460.00	<120	41.40	<0.01	<0.7	7.30	7.50	16.30	56.70	478.00	9.10
BH12	08/10/2018	313.00	0.06	232.00	98.20	1968.00	1450.00	<120	41.00	<0.01	1.60	7.10	7.80	21.30	58.20	451.00	8.70
BH13	12/01/2018	338.00	<0.06	87.70	34.40	681.00	672.00	<120	34.00	<0.01	<0.7	7.50	7.50	2.72	9.15	5.10	2.30
BH13	19/04/2018	258.00	<0.06	83.60	51.90	735.00	692.00	<120	32.60	<0.01	0.90	7.30	7.70	3.56	14.60	9.30	2.80
BH13	16/07/2018	445.00	<0.06	120.00	58.90	1013.00	898.00	<120	45.10	<0.01	<0.7	7.00	7.70	3.39	16.30	9.00	10.30
BH13	08/10/2018	450.00	<0.06	124.00	66.40	1285.00	920.00	<120	45.40	<0.01	1.70	7.00	7.30	2.95	21.10	16.30	3.20
BH14	12/01/2018	424.00	<0.06	127.00	7.10	775.00	791.00	<120	31.90	<0.01	4.20	7.40	7.28	0.82	4.83	<4.4	2.00
BH14	19/04/2018	367.00	<0.06	108.00	12.30	747.00	638.00	<120	28.60	<0.01	4.00	7.60	7.70	0.71	4.59	<4.4	6.90
BH14	16/07/2018	Not sampled – access to location not granted															
BH14	08/10/2018	Location inaccessible – cannot get to the sample point															
BH15	12/01/2018	323.00	<0.06	104.00	14.40	624.00	616.00	<120	18.50	<0.01	1.80	7.60	8.50	0.99	8.38	8.20	2.50
BH15	19/04/2018	231.00	<0.06	95.80	16.90	603.00	605.00	<120	16.60	<0.01	1.20	7.80	7.70	0.90	7.98	8.40	3.70
BH15	16/07/2018	Not sampled – access to location not granted															
BH15	08/10/2018	Insufficient liquid to obtain a sample															
BH3	12/01/2018	262.00	<0.06	93.30	65.60	681.00	678.00	157.00	24.10	<0.01	<0.7	7.60	7.80	1.48	23.50	20.90	3.40
BH3	19/04/2018	211.00	<0.06	67.30	33.60	556.00	535.00	<120	18.30	<0.01	<0.7	7.40	7.90	1.10	15.00	54.90	7.40

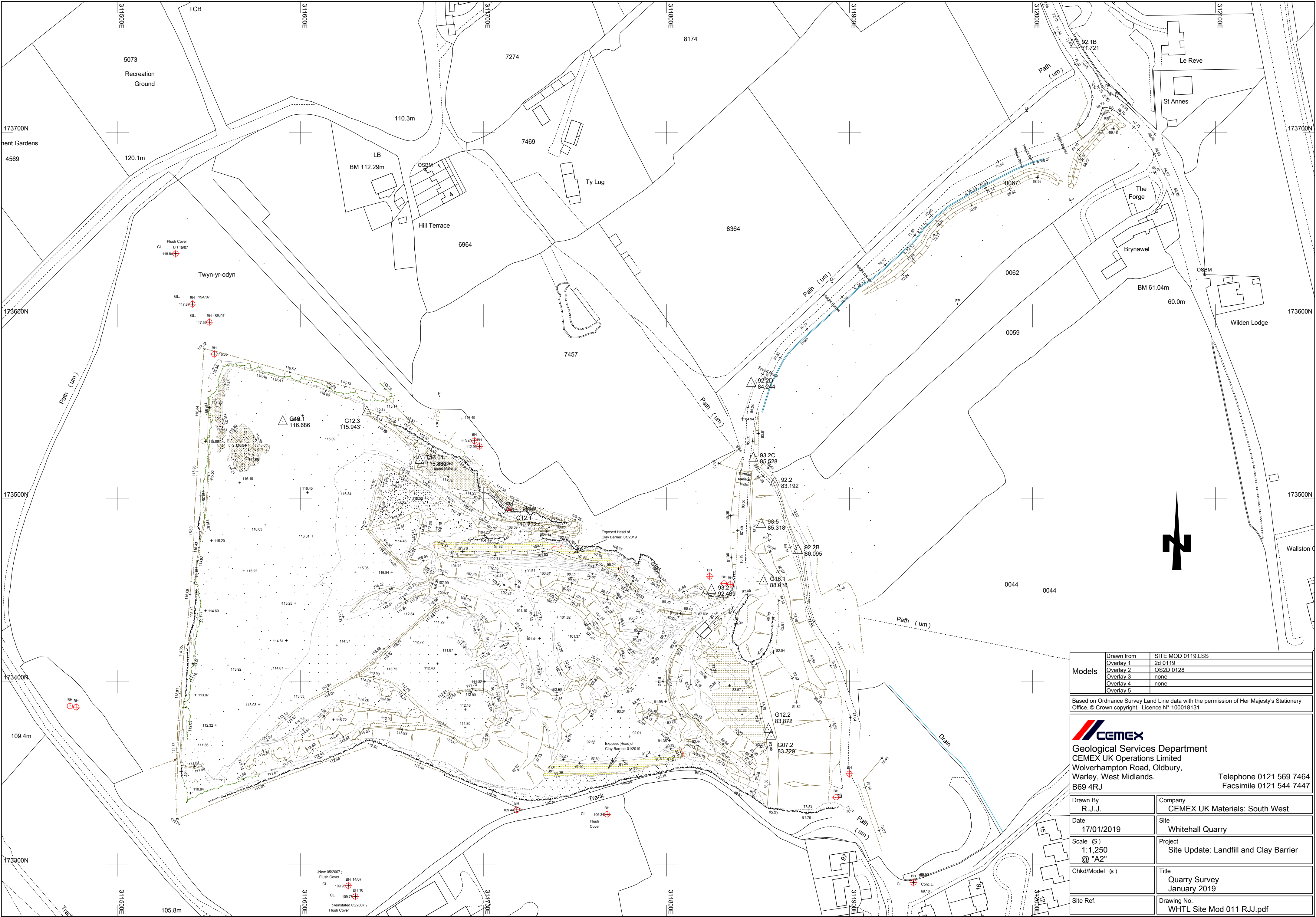
[illegible]

Appendix C Table 2 Annual groundwater quality data 2018

Location	Date	Cadmium µg/l	Chromium mg/l	Copper mg/l	Lead mg/l	Manganese mg/l	Nickel mg/l	Zinc mg/l
BH1	19/04/2018	Damaged headworks prohibiting access						
BH12	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.018	0.006	<0.018
BH13	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.01	0.004	<0.018
BH14	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.013	<0.003	<0.018
BH15	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.011	0.005	<0.018
BH3	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.008	<0.003	<0.018
BH3A	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.01	0.004	<0.018
BH6	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.011	0.005	<0.018
BH9	19/04/2018	<0.6	<0.002	<0.009	<0.006	0.015	0.004	<0.018

Appendix D

Topographical Survey



Models	Drawn from	SITE MOD 0119.LSS
	Overlay 1	2d 0119
	Overlay 2	OS2D 0128
	Overlay 3	none
	Overlay 4	none

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Geological Services Department
CEMEX UK Operations Limited
Wolverhampton Road, Oldbury,
Warley, West Midlands.
B69 4RJ

Telephone 0121 569 7464
Facsimile 0121 544 7447

Drawn By R.J.J.	Company CEMEX UK Materials: South West
Date 17/01/2019	Site Whitehall Quarry
Scale (S) 1:1,250 @ "A2"	Project Site Update: Landfill and Clay Barrier
Chkd/Model (S)	Title Quarry Survey January 2019
Site Ref.	Drawing No. WHTL Site Mod 011 RJJ.pdf